Macroinvertebrate Index of Biotic Integrity for the Lake Agassiz Plain Ecoregion (48) of North Dakota

Final: May 2006

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ACKNOWLEDGEMENTS

I would like to thank the many individuals and organizations who contributed to this report. Eric Pearson and Scott Elstad, formerly with the North Dakota Department of Health, Division of Water Quality were responsible for the field sampling, data entry and preliminary data analysis. Mike Ell provided project guidance and oversight. Joe Gross performed database management and assistance. Numerous staff members and temporary employees with the North Dakota Department of Health, Division of Water Quality provided assistance with field sampling. Funding for this project was provided by U. S. Environmental Protection Agency Region 8.

1.0 INTRODUCTION

The Lake Agassiz Plain ecoregion in North Dakota (Figure 1) occupies the nearly level basin of ancient Glacial Lake Agassiz. Relief of 50 to 100 feet is found along the margins of the ecoregion but otherwise is generally absent. Streams originating from within the ecoregion are mostly intermittent and drain watersheds ranging up to a few hundred square miles. Perennial streams in this region generally originate in adjacent ecoregions. Average annual precipitation is from 20 to 22 inches, approximately half of which occurs in the growing season, April-September (Omernik and Gallant 1988).

Soils have been formed from lacustrine sediments and sandy, gravelly beach deposits. Poor to imperfect drainage occurs in areas of silt loam and clay, and poor to excessive drainage in areas of sandy loam or loamy sand. Stream water quality in this region is impacted by dryland farming practices. Runoff delivery of fertilizers, insecticides, and other farm chemicals, employed extensively in this region, alters water chemistry in many streams. This process is generally accelerated where man-made drainage assists in areas of naturally poor soil drainage (Omernik and Gallant 1988).

Aquatic life is a beneficial use that is assigned to all North Dakota streams by *State Water Quality Standards* (North Dakota Department of Health 2001). While an assessment of aquatic life use can be conducted indirectly with chemical data (e.g., dissolved oxygen and dissolved metals data), direct measures of the biological community are believed to be more accurate. Aquatic life use or biological integrity is defined by Karr and Dudley (1981) as the ability to support and maintain a balanced, integrated, adaptive community of organisms, having a species composition, diversity, and functional organization comparable to that of natural habitats of the region. Human disturbance of streams and landscapes alters key attributes of aquatic ecosystems (i.e., water quality, habitat structure, hydrological regime, energy flow, and biological interactions) which can result in decreased biotic integrity.

In order to develop biological indicators capable of assessing the biological conditions of state’s rivers and streams, the North Dakota Department of Health (NDDoH) is developing a calibrated multi-metric index of biotic integrity (IBI) based on aquatic macroinvertebrate data for each ecoregion. Macroinvertebrates are common inhabitants of rivers and streams and vital links in the movement of energy through the food web. Advantages to using macroinvertebrates in IBI development include their high diversity, rapid colonization, and variability in tolerance to perturbation (Rosenberg and Resh 1993).

Once an IBI has been developed, it becomes a valuable assessment tool. A multi-metric IBI assumes that multiple measures of the biological community (i.e. metrics) (e.g., species richness, species composition, tolerance levels, trophic structure) will respond to increased pollution or habitat alterations. Metric development reduces the number of biological community attributes that need evaluation to only those that are sensitive to human disturbance or impairment. Metrics selected for the IBI are given a standardized score. Individual metric scores are then combined into an overall IBI score. These overall IBI scores can be matched with a qualitative rating such as those associated with aquatic life use support (e.g., fully supporting, fully supporting but threatened, and not supporting).

Benthic macroinvertebrate metrics generally fall into five distinct categories including richness metrics, composition metrics, tolerance/intolerance metrics, feeding measure metrics and habit metrics. Richness metrics, or the number of distinct taxa, represents the diversity within an aquatic assemblage (Resh et al 1995). Richness is a key category of metrics in a macroinvertebrate IBI. Taxa richness is usually based on species level identification but can also be evaluated as groupings of higher taxonomic levels (e.g., genus, family, order). High levels of diversity suggest that niche space, habitat and food sources are adequate to support a diverse community of macroinvertebrates (Barbour *et al.* 1999).

Composition or relative abundance metrics provide information on the relative contribution of the various taxa to the total fauna. Although individual abundances may vary in magnitude, the proportional representations of taxa in a healthy and stable assemblage should remain consistent. A large percentage of a single dominant taxa can be equated with the dominance of a pollution tolerant organism and lowered diversity (Barbour *et al.* 1999).

Tolerance/intolerance metrics are intended to represent the sensitivity of the macroinvertebrate assemblage to disturbance. Measurements include numbers of pollution tolerant and intolerant taxa or their percent composition. High proportions or numerous taxa of tolerant macroinvertebrates can indicate possible stressors such as organic pollution or increased sedimentation (Barbour *et al.* 1999).

Feeding measures or trophic dynamics metrics provide information on the balance of feeding strategies by evaluating the number of taxa and percent composition of functional feeding groups. Functional feeding groups are not based on the type of food ingested, but rather on the morpho-behavioral mechanisms that a macroinvertebrate uses to acquire food (Merrit and Cummins 1996). Examples of functional feeding groups include predators, scrapers, shredders, filterers and gatherers. Stressors that cause instability in food dynamics will cause an alteration in the composition of functional feeding groups from the least disturbed or reference condition (Barbour *et al.* 1999).

Habit or modes of existence metrics evaluate the composition of morphological adaptations that allow macroinvertebrates to attach, move, and/or conceal themselves in their environment (Merritt and Cummins 1996). Habit metric categories include swimmers, skaters, clingers, climbers and burrowers. Changes in the number of taxa or percent composition of habit metrics can indicate changes in available habitat niches.

The purpose of this report is to present a benthic macroinvertebrate IBI that has been developed for the Lake Agassiz Plain ecoregion in North Dakota. It is based on metrics from the categories listed above. IBI development is intended to be a dynamic process and additional refinement is likely as new sites and data are added.

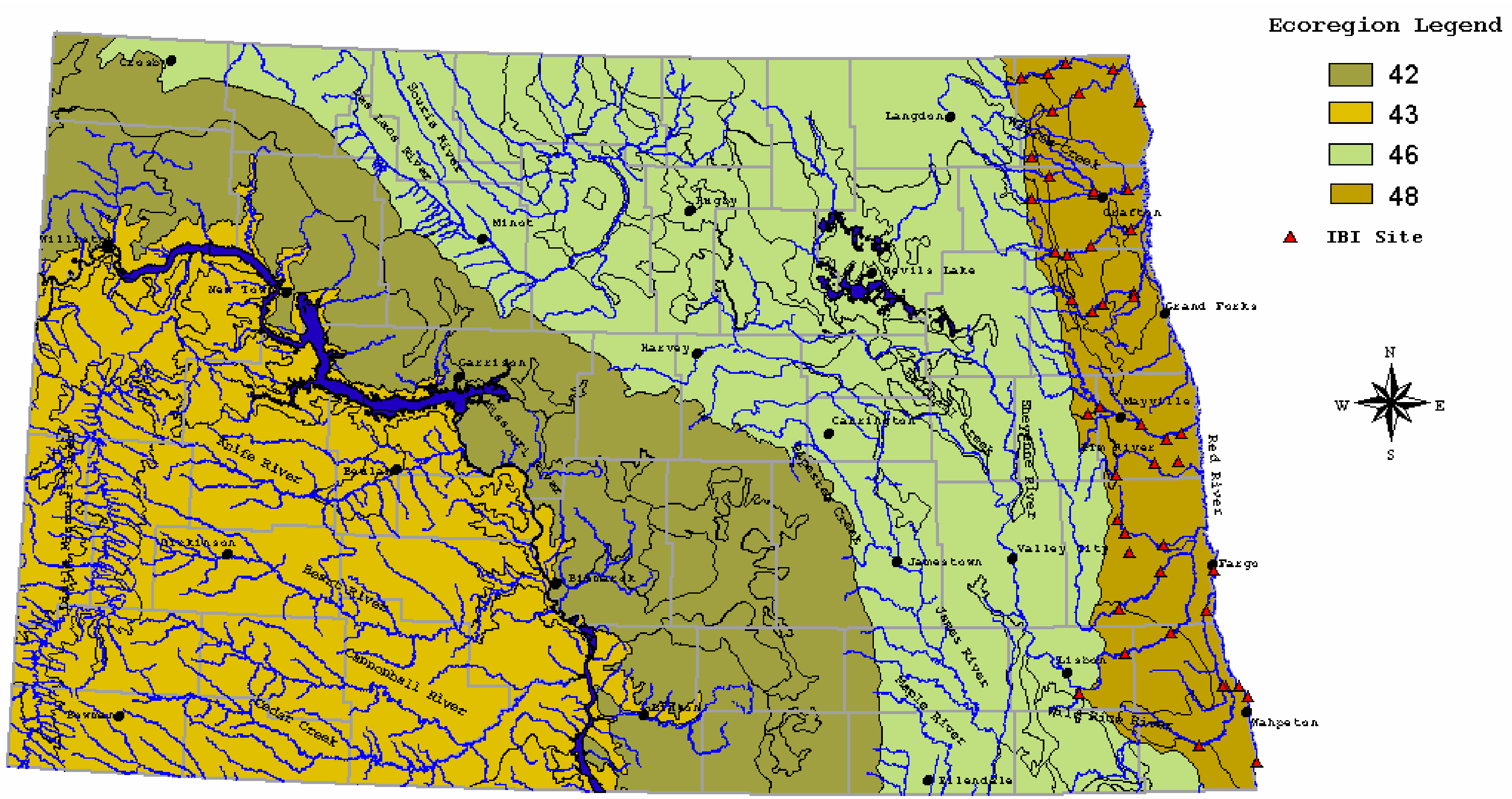

Figure 1. IBI Sampling Sites for the Lake Agassiz Plain Ecoregion (48) in North Dakota.

2.0 METHODS

The data used to develop the macroinvertebrate IBI presented in this report are based on data collected from 1995 through 2003. A total of 333 sites were sampled statewide with 431 samples collected. Sites were divided into two distinct groups, riffle/run (RR) or glide/pool (GP).

2.1 Macroinvertebrate Field Sampling

Benthic macroinvertebrate field samples were collected by NDDoH Surface Water Quality Management Program personnel in 1995, 1996 and 2002 within the Lake Agassiz Plain ecoregion. A total of 41 GP samples were collected from 33 sites and 12 RR samples were collected from 9 sites. Sampling was conducted by apportioning 20 jabs with a D-frame net among all habitat types present (Barbour *et al.* 1999). For a more complete description of the field sampling procedure, see Appendix A.

2.2 Macroinvertebrate Laboratory Analyses

Laboratory analysis of macroinvertebrate samples was conducted on a 300 count sub-sample (Appendix A). These sub-samples were obtained by spreading the sample evenly on a gridded pan and picking 300 individuals from randomly selected grids. Final organism identification was done at the lowest taxonomic level practical (genus/species preferred). Laboratory analysis of macroinvertebrate samples was contracted out to Dr. Andre Delorme, Valley City State University, and Larry Brooks, Western Aquatic Technology and Environmental Resource Specialists.

2.3 Data Management and Analysis

The biological, physical and chemical data collected were entered into the Ecological Data Application System (EDAS). EDAS is an Access based program developed by Tetra Tech, Inc. under contract with the U. S. Environmental Protection Agency (EPA). EDAS is designed to facilitate data analysis, particularly the calculation of biological metrics and indices. Pre-designed queries that calculate a wide variety of biological metrics are included with EDAS (Faulkner and Lepo 2000). EDAS was used to evaluate a total of 62 candidate metrics (Appendix C) in the five categories: taxa richness, percent composition, tolerance values, feeding groups, and habit measures. Microsoft Excel 2002 and Analyse-It were also used to analyze the data (Microsoft Corporation 2002, Analyse-It Software, Ltd 2003).

2.4 Human Disturbance Scoring Analysis

A human disturbance score was developed to assess the level of degradation at each site. This process consisted of a field evaluation component and a remote sensing component. The field evaluation involved sampling personnel filling out a habitat assessment field data sheet. Each site was classified as a high gradient riffle/run (RR) or a low gradient glide/pool (GP) stream and the appropriate form was used. A sample of these forms can be found in Rapid Bioassessment Protocols (RBP) for Use in Wadeable Streams and Rivers (Barbour *et al.* 1999).

The remote sensing component involved the development of a Landscape Index (LSI) that evaluated landuse adjacent to and influencing each stream sample reach. Landuse for each sample reach was evaluated within a 3 km circular buffer by calculating landuse metrics with the Analytical Tool Interface for Landscape Assessment (ATtILA) (Ebert *et al.* 2001). A final set of landscape metrics were selected by evaluating their range of response, correlation to other metrics and through professional judgment (Appendix B).

The LSI and RBP habitat assessment score for each site were combined to form the final Human Disturbance Index (HDI) (Appendix E). Sites were separated into ecoregions and assigned a value of good, fair or poor according to their HDI score. The boundaries for good, fair and poor sites were set at the 90th percentile and above for good sites and the 10th percentile and below for poor sites. When a sufficient numbers (at least 4 good and 4 poor) of sites were not available by this method, levels were determined by graphing the range of habitat scores and then looking for the natural breakpoints in the data (Table 1, Figure 2).

2.5 Metric Selection

Candidate metrics underwent a series of data reduction steps to select the final metrics used to construct the IBI. First, "box and whisker" plots for each candidate metric were plotted to evaluate the range of data (Appendix D). Box and whisker plots were also evaluated based on the amount of overlap exhibited between sites with good and poor HDI scores. All metrics with complete overlap were eliminated due to the lack of response to disturbance. In addition, metrics with insufficient ranges were eliminated. All metrics with complete separation or minimal overlap were kept for further evaluation. Second, remaining candidate metrics were evaluated using the Mann-Whitney U test. This is a nonparametric test that evaluates the difference between the medians of two independent data sets. Metrics were eliminated if the P-value was less than 0.20. Third, metrics showing a significant relationship to human disturbance were selected. This was evaluated by performing a Spearman Rank correlation with the HDI and the evaluated metric. Metrics with P-values greater than 0.05 were eliminated (Appendix E). Finally, a correlation matrix was completed on all metrics that were not eliminated due to low responsiveness or other poor predictive characteristics. When metrics pairs were highly correlated ($r>0.80$) one of the pair was eliminated to reduce redundancy within the final set of metrics.

Once the final metrics were determined, raw metric values were transformed into standardized metric scores. All metric scores were computed using the following equations developed by Minns *et al.* (1994) that standardized metrics on a scale of 0 to 100.

Metrics that decrease with impairment:

$M_s = (M_R/M_{MAX}) \times 100$

Metrics that increase with impairment:

$M_s = (M_{MAX} - M_R) / (M_{MAX} - M_{MIN}) \times 100$

Where:

M_s = standardized metric value
M_R = the raw metric value
M_{MAX} = the maximum value
M_{MIN} = the minimum value

Maximum (M_{MAX}) and minimum (M_{MIN}) values were set at the 95^{th} and 5^{th} percentiles, respectively, of the entire data set. The overall IBI score was the mean of the standardized metric scores that comprise the final IBI.

If the data allowed, IBI scores for sites that had replicate data for consecutive years or within the same year were used to evaluate the variation in the IBI score. These comparisons allowed an evaluation of how the IBI performed between and within years. Also, at least one site with a good HDI score, one site with a poor HDI score and at least ten percent of sites with fair HDI scores were randomly selected to be left out of the IBI development process. These sites were considered validation sites and were used to evaluate performance of the final IBI.

3.0 RESULTS

Adequate data were not available to develop IBI metrics for high gradient riffle/run habitat sites due to their low occurrence in this ecoregion, therefore these results pertain only to low gradient glide/pool habitat sites. A total of 28 metrics showed separation in the box plots and had an adequate range of values (Appendix D). Mann-Whitney tests yielded 28 metrics with P-values less than 0.20 (Table 2). Spearman rank correlations reduced the metrics to 16 candidate metrics (Table 2). Evaluation of correlation matrices left nine metrics (Table 3). Percent burrowers and burrower taxa both passed the metric elimination steps. In the interest on not having two metrics from the same habit group in the final IBI, only the burrower taxa metric was retained because it was more responsive. The sprawler taxa metric was also eliminated from the final IBI. This metric was correlated with both the percent Diptera and the total taxa metric at just under the threshold level ($r<0.80$) in the correlation matrix. The final IBI would have been weighted heavily toward habit-based metrics by including the sprawler taxa metric. Table 4 provides a list of final metrics used in the IBI for glide\pool habitats in the Lake Agassiz Plain ecoregion. Maximum and minimum values used for scoring each metric are represented in Table 4. Results of individual IBI scores are depicted for sites in the Lake Agassiz Plain ecoregion in Appendix F.

The IBI scoring range for all GP sites in the Lake Agassiz Plain ecoregion was 7.9 to 88.1 with a mean of 45.4 and a median of 45.1. The IBI scoring range for sites with good HDI scores was 44.6 to 88.1 with a mean of 67.6 and a median of 72.7. IBI scores for sites with poor HDI scores ranged from 7.9 to 37.3 with a mean of 27.8 and a median of 29.2. Fair HDI scoring sites had IBI scores ranging from 9.4 to 84.7 with a mean of 43.8 and median of 45.9. A 1-way analysis of variance (AOV) showed a significant effect due to habitat ranks ($F=5.64$, $P=0.01$). A Tukey multiple comparison test ($\alpha=0.05$) was used to compare the mean IBI score. Significant differences in mean IBI scores occurred between sites with good and poor HDI scores and between good and fair sites. There was no difference in IBI scores between sites with fair and poor habitat scores.

Data needed to make between year comparisons were available for the GP sites. Results of this analysis are represented in Figure 3. Between-year comparisons showed similar trends in scoring with sites scoring consistently higher in 1996 than in 1995. This suggests the current IBI may not be robust enough to minimize between year comparisons. This was similar to findings of previous drafts using RBP habitat scores as the only surrogate for human disturbance.

Validation data showed similar variation and linear relationships between IBI scores and HDI scores as the IBI development sites (Figure 4). It should be noted, however, that due to its small sample size, the regression between IBI and HDI scores for the validation sites is not significant ($P>0.05$). Further sampling would allow for more thorough investigation.

Table 1. Lake Agassiz Plain Ecoregion (48) Glide/Pool Qualitative Human Disturbance Index (HDI) Score Rankings and Associated Scoring Ranges.

Habitat Rank	Human Disturbance Index Score Ranges
Good	≥112.5
Fair	83.4 - 112.4
Poor	≤83.3

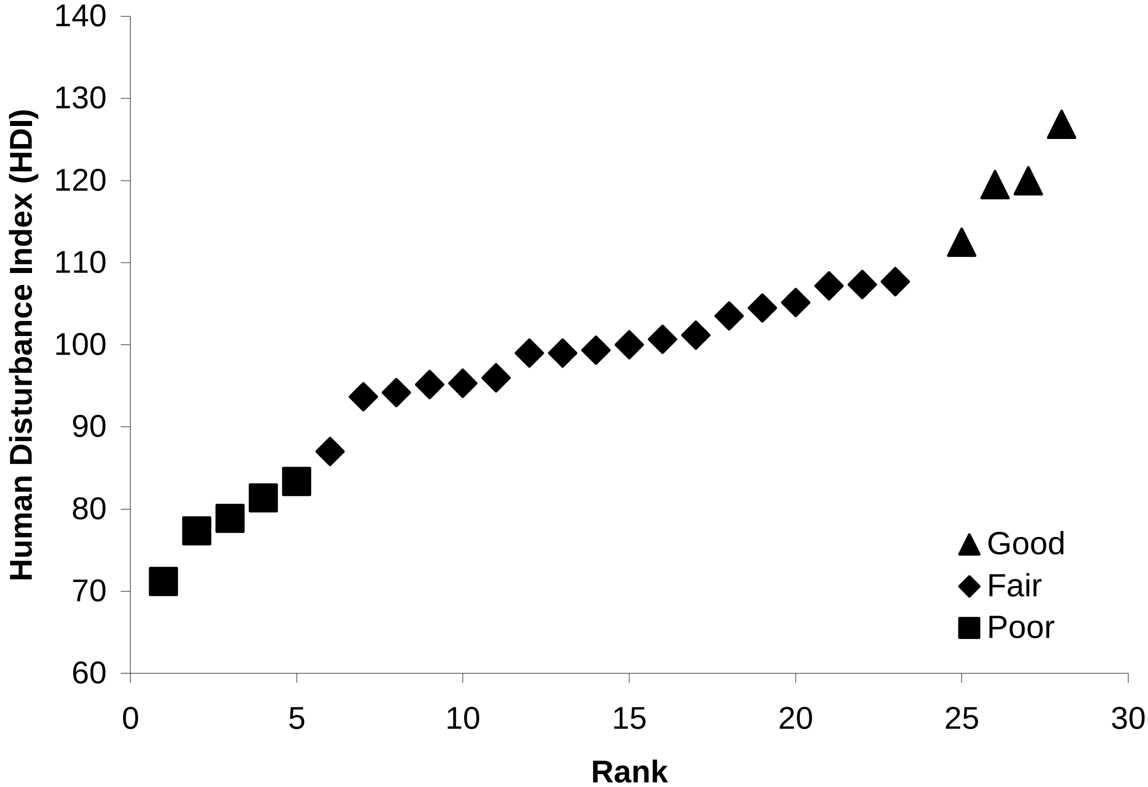

Figure 2. Distribution of the Human Disturbance Index Ranked from Lowest to Highest Score.

Table 2. Results of Mann-Whitney U Test and Spearman Rank Correlation to the Human Disturbance Index (HDI).
(Asterisks denote P-values less than 0.05. Bold metrics indicate final IBI metrics.)

Metric	Abbreviation	Mann-Whitney U Test (P-Value)	Spearman Rank Correlation	
			R-value	P-Value
Shannon- Weiner Index	Shan_e	0.0952	0.53	0.0034*
Margalef's Index	D-Mg	0.0159	0.48	0.0100*
Simpson's Index	D	0.0952	-0.51	0.0056*
Hilsenhoff Biotic Index	HBI	0.0952	-0.13	0.5141
Beck Biotic Index	BeckBI	0.0556	0.22	0.2543
Evenness	Evenness	0.0952	0.48	0.0097*
Percent Chironomidae	ChiroPct	0.0952	0.45	0.0165*
Percent Diptera	DipPct	0.0318	0.48	0.0097*
Percent Ephemeroptera	EphemPct	0.0952	0.21	0.2728
Percent Ephemeroptera, Plecoptera, and Trichoptera	EPTPct	0.0952	0.17	0.3884
Percent Trichoptera	TrichPct	0.0952	0.27	0.1703
Percent Burrowers	BrwwrPct	0.0952	0.41	0.0289*
Percent Clingers	ClngrPct	0.0952	0.30	0.1267
Percent Multivoltine Taxa	MultVolPct	0.0952	-0.28	0.1480
Percent Swimmers	SwmmrPct	0.0952	-0.43	0.0238*
Percent Dominant Taxa	Dom01Pct	0.0952	-0.48	0.0104*
Chironomidae Taxa	ChiroTax	0.0317	0.46	0.0146*
Diptera Taxa	DipTax	0.0080	0.51	0.0053*
Ephemeroptera Taxa	EphemTax	0.0952	0.23	0.2301
Ephemeroptera, Plecoptera, and Trichoptera Taxa	EPTTax	0.0952	0.26	0.1837
Collector Taxa	CllctTax	0.0080	0.64	0.0002*
Filterer Taxa	FiltrTax	0.0556	0.22	0.2577
Scraper Taxa	ScrapTax	0.0952	0.33	0.0914
Burrower Taxa	BrwwrTax	0.0318	0.46	0.0140*
Clinger Taxa	ClngrTax	0.0159	0.51	0.0061*
Sprawler Taxa	SprwlTax	0.0080	0.62	0.0005*
Trichoptera Taxa	TrichTax	0.0952	0.28	0.1530
Total Taxa	TotalTax	0.0159	0.49	0.0082*

Table 3. Lake Agassiz Plain Ecoregion (48) Glide/Pool Correlation Matrix. (Numbers in bold represent correlations with r>0.80. Abbreviation definitions found in Table 2.)

	Shan_e	D-Mg	D	Evenness	ChiroPct	DipPct	BrrwrPct	SwmmrPct	Dom01Pct	ChiroTax	DipTax	CllctTax	BrrwrTax	ClngrTax	SprwlTax	TotalTax
Shan_e	1.00															
D-Mg	**0.90**	1.00														
D	**-0.94**	-0.73	1.00													
Evenness	**0.92**	0.76	-0.95	1.00												
ChiroPct	0.57	0.48	-0.49	0.49	1.00											
DipPct	0.59	0.52	-0.50	0.49	**0.97**	1.00										
BrrwrPct	0.40	0.26	-0.42	0.39	0.59	0.55	1.00									
SwmmrPct	-0.42	-0.30	0.39	-0.41	-0.35	-0.36	-0.24	1.00								
Dom01Pct	**-0.92**	-0.70	**0.98**	**-0.92**	-0.53	-0.54	-0.47	0.37	1.00							
ChiroTax	0.63	0.70	-0.50	0.57	0.77	0.78	0.21	-0.29	-0.50	1.00						
DipTax	0.68	0.78	-0.51	0.54	0.73	0.78	0.28	-0.31	-0.51	**0.93**	1.00					
CllctTax	0.74	**0.82**	-0.58	0.63	0.70	0.69	0.33	-0.38	-0.59	**0.84**	**0.84**	1.00				
BrrwrTax	0.68	0.69	-0.54	0.49	0.65	0.64	0.67	-0.21	-0.60	0.61	0.73	0.75	1.00			
ClngrTax	0.60	0.69	-0.47	0.45	0.18	0.26	0.12	-0.54	-0.43	0.35	0.48	0.53	0.38	1.00		
SprwlTax	0.62	0.75	-0.41	0.44	0.45	0.53	0.24	-0.34	-0.41	0.59	0.79	0.69	0.59	0.53	1.00	
TotalTax	**0.86**	**0.97**	-0.66	0.64	0.47	0.51	0.30	-0.28	-0.64	0.64	0.77	0.80	0.76	0.70	0.79	1.00

4.0 SUMMARY

The purpose of this project is to develop a set of benthic macroinvertebrate multimetric IBIs that can be used to assess the biological condition of perennial rivers and streams in North Dakota. This report addresses those methods used and results found for the Lake Agassiz Plain ecoregion (48) within North Dakota. Exhaustive statistical analyses were not conducted on these data. Tests of significance are often overused by ecologists (Fore *et al.* 1996) and short-circuit the process of looking at and interpreting the data. Such tests address detection of impact rather than their magnitude or relevance (Stewart-Oaten 1986). This was considered when we incorporated visual assessments (box plots) in evaluating metrics and used less rigorous p-values when assessing the Mann-Whitney tests. More emphasis should be centered on understanding and evaluating the biological data and condition of the sampling sites and less on the statistical procedures used to analyze them.

Development of an IBI is a widely accepted practice throughout the United States. Biocriteria are useful tools in allowing managers to assess human disturbances to our aquatic environments. Because biological systems are dynamic, an IBI should be continually revised and updated as additional data becomes available. Efforts should also focus on sampling sufficient numbers of “least disturbed” or “best available” reference sites as well as impaired sites with high levels of human disturbance. Efforts to resample reference and impaired sites between and within years should also be implemented to permit the evaluation of how IBI scores vary over time.

An IBI is a useful tool for evaluating and monitoring our lotic environments. It should, however, be used to complement and enhance other data (e.g., chemical data, habitat data, landscape data) to determine not only the biological condition of the aquatic resource, but to understand the cause and source of stressors on the biology of impaired rivers and streams. Other biological conformation (e.g., fish community data) can also be collected when performing stream surveys. By combining information from different biological communities, an integrated approach to examining aquatic life use can be developed.

Table 4. Lake Agassiz Plain Ecoregion (48) Glide/Pool Maximum and Minimum Values Used to Standardize Metrics.

Glide/Pool Metrics		Category	Reaction to Perturbation	Minimum value	Maximum value
1	Percent Diptera	Composition	Decrease	0	59.63
2	Percent Swimmers	Habit	Increase	0	95.18
3	Percent Dominant Taxa	Composition	Increase	15.65	84.68
4	Collector Taxa	Trophic	Decrease	0	13
5	Burrower Taxa	Habit	Decrease	0	8
6	Clinger Taxa	Habit	Decrease	0	8
7	Total Taxa	Richness	Decrease	4	27

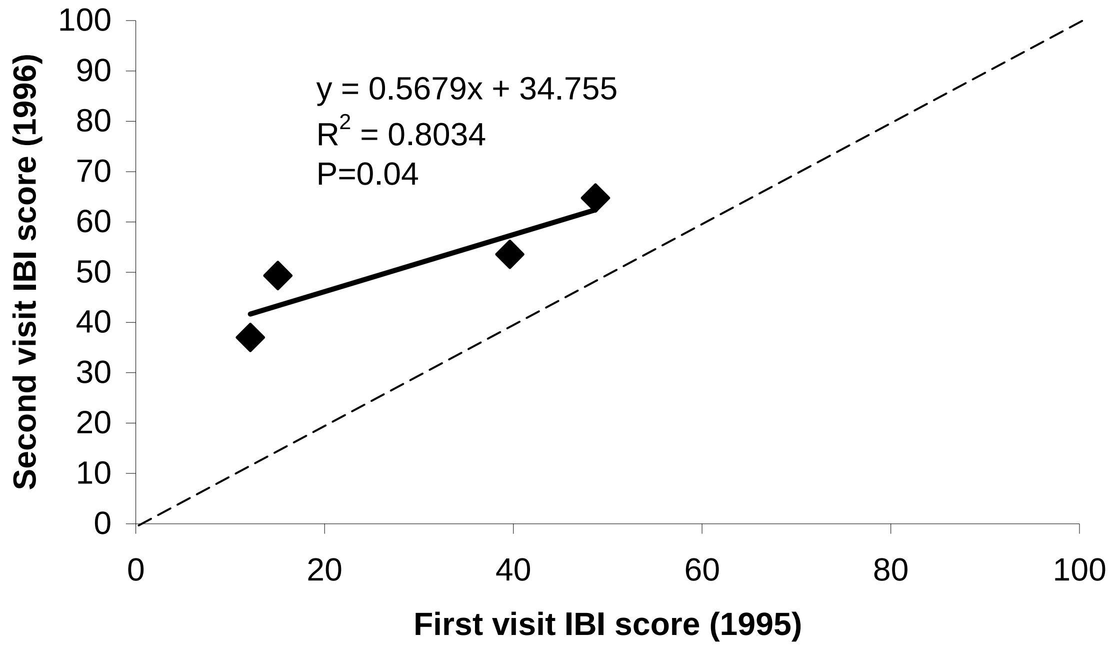

Figure 3. Between-year Variation of the IBI Developed for the Glide/Pool Stream Sections of Ecoregion 48 within North Dakota. (Dashed line indicates the expected 1 to 1 relationship. Solid line indicates the regression line. Results of the linear regression are reported above.)

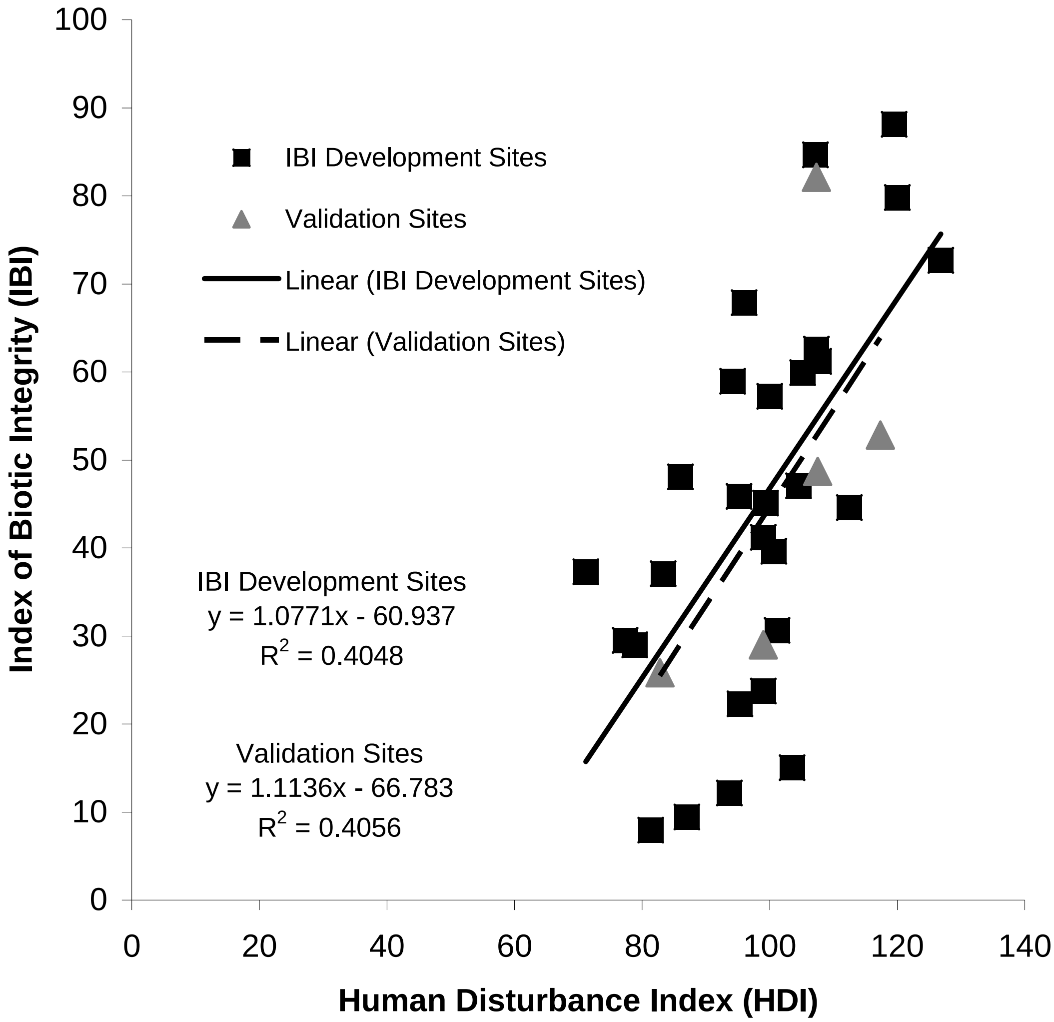

Figure 4. Comparison of IBI Development Sites to Validation Sites. (Lines indicate linear regressions. Results of each linear regression are reported above.)

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Appendix A

Standard Operating Procedures for the Collection and Laboratory Analysis of Macroinvertebrate Samples Including Example Data Forms

7.19 STANDARD OPERATING PROCEDURES FOR THE COLLECTION OF A MACROINVERTEBRATE SAMPLE FROM WADABLE RIVERS AND STREAMS

Summary

Macroinvertebrates are excellent indicators of aquatic health. Additionally, due to the range of life spans and varying needs throughout their life span, macroinvertebrates are excellent indicators of chronic and acute pollution impacts.

In rivers and streams which naturally contain cobble (riffle/run) habitat, a single sample collected from this habitat is considered representative of the stream reach. Many rivers and streams in the state, however, do not naturally contain cobble substrate. These rivers and streams are typically low gradient streams with sandy or silty sediments. In cases where cobble substrate represents less than 30% of the sampling reach in reference streams (i.e., least impaired streams which represent the ecoregion or basin) the multi-habitat method for collecting macroinvertebrate samples should be used (Section 3.19.2). It is important to recognize that the appropriate sampling method (single or multi-habitat) should be selected based on the habitat availability of the reference condition and not of potentially impaired streams. For example, the multi-habitat method should not be used for stream reaches where the extent of cobble substrate was reduced due to anthropogenic sediment deposition. Conversely, the single-habitat method should not be used where the stream reach contains artificially introduced rock or cobble material.

The following methods have been developed, in part, based on the Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition (Barbour *et al.* 1999).

7.19.1 Field Collection Procedures for Single-Habitat Macroinvertebrate Samples

Equipment list

__ D-Frame net, Kick net, Surber Bottom Sampler, or Hess Bottom Sampler (500-600 µm mesh opening)
__ Waders (chest-high or hip boots)
__ Sample containers (1 and 2 liter plastic jars)
__ Sample container labels (waterproof Nalgene Polypaper)
__ 95 % Ethanol
__ Sieve bucket (500 µm mesh opening)
__ Forceps
__ Permanent marker (black)
__ Pencils, clipboard
__ Field Recording and Log Forms
__ Camera
__ Global Positioning System (GPS) Unit (optional)

Procedures

1. Once the sampling reach has been selected (Note: The area should be at least 100 meters

upstream from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality.), complete the Biological Monitoring Field Collection Data Form (Figure 7.19.1). To record the latitude and longitude, use a hand held Global Positioning System (GPS) and determine latitude and longitude at the furthest downstream point of the sampling reach. On the recording form, draw a site map of the sampling reach. The map should include in-stream attributes (e.g., riffles, fallen trees, pools, bends), important structures, attributes of the bank and near bank area, and the location of all areas sampled. The map should also include an arrow in the direction of flow and an arrow depicting north.

2. A composite sample is collected from a minimum of three “kicks” each located at various velocities, in the riffle or series of riffles. (Note: The composite sample should consist of a minimum of 300 organisms; therefore, additional kick samples may be required.) A “kick” is a stationary sampling accomplished by disturbing area in front of the full width of the net to a distance 1 meter upstream of the net. Using the toe or heel of the boot, dislodge the upper layer of cobble or gravel and scrape the underlying bed. Larger rocks should be picked up and rubbed by hand to remove attached organisms. This method presumes a D-frame net with a 454 cm^2 opening is used, however, other gear types (e.g., kick-net, Surber sample, Hess sampler, etc.) may be used depending on project specific Quality Assurance Project Plans.

3. The individual kicks collected for each area in the riffle or series of riffles is composited into a single homogeneous sample. After every kick, place the sample in a sieve bucket, or in the sample net, wash the collected material with clean stream water 2-3 times. Remove large debris after rinsing and inspecting it for organisms, placing all organisms found into the sample container.

4. Transfer the sample from the sieve bucket or net to the sample container. Once all the samples are composited in the sample container, decant excess water from the container and preserve in enough 95 % ethanol to cover the sample. (Note: Forceps may be needed to remove organisms from the net.)

5. Place a Nalgene Polypaper label in the sample container and label the outside of the container with black permanent marker. Both labels should contain the station identification number and description, the field number, date and time of collection, and the collector(s) name. The outside of the container should also contain the words: “preservative: 95% ethanol.” If more than one container is used for a sample, each container should contain all the information for the sample and should be numbered 1 of 2, 2 of 2, etc.

6. Record each sample on the Macroinvertebrate Sample Log Form (Figure 7.19.2). Include information such as field number, station identification and description, date and time, and number of containers.

North Dakota Department of Health
Division of Water Quality
Biological Monitoring Field Collection Data Form

Station ID: ______________________________ Field Number: __________________________________

Waterbody Name: ____

Station Description: ____

Latitude: ___________________________________ Longitude: _________________________________

County: _______________ Township: __________ Range: _______________ Section: _______________

River Basin: _____________________________________ Ecoregion: _____________________________

Weather (air temp, wind, etc.): ____

Flow (cfs): _____ Water Temp: ______ pH: ______ Specific Cond.: ______Dissolved Oxygen: _________

Reach Length (m): _________ Average Reach Width (m): ________ Average Reach Depth (m): ________

Stream Habitat Type (%): Riffle: _____ Pool: _____ Snag: _____Aquatic Vegetation: _____

Undercut Bank: _____ Overhanging Vegetation: _____ Other: _____________________

Bottom Substrate Type (%): Boulder: ____ Cobble: ____ Gravel: ____ Sand: ____ Silt: ____ Clay: ____

Collection Method: _________Time Start: __________ Time Stop:____________ Total Time:__________

Habitat Assessment: Yes or No Macroinvertebrate Sample: Yes or No Water Chemistry: Yes or No

Sampler(s): ____

Comments: ____

Figure 7.19.1. Macroinvertebrate Field Collection Data Recording Form

North Dakota Department of Health
Division of Water Quality
Macroinvertebrate Field Sample Log

Field Number	Station ID and Description	Date/ Time	Collection Method	Comments

Figure 7.19.2. Macroinvertebrate Sample Log

7.19.2 Field Collection Procedures for Multi-Habitat Macroinvertebrate Samples

Equipment list

__ D-frame net (454 cm^2 opening and 600 µm mesh)
__ Waders (chest-high or hip boots)
__ Sample containers (1 and 2 liter plastic jars)
__ Sample container labels (water proof Nalgene Polypaper)
__ 95 % Ethanol
__ Sieve bucket (500 µm mesh opening)
__ Forceps
__ Permanent magic marker (black)
__ Pencils, clipboard
__ Field Recording and Log Forms
__ Camera
__ Global Positioning System (GPS) Unit (optional)

Procedures

1. Once the sampling reach has been selected (Note: The area should be at least 100 meters upstream from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality.), complete the Macroinvertebrate Field Collection Data Recording Form (Figure 7.19.1). To record the latitude and longitude, use a hand held Global Positioning System (GPS) and determine latitude and longitude at the furthest downstream point of the sampling reach. On the recording form, draw a site map of the sampling reach. The map should include in-stream attributes (e.g., riffles, fallen trees, pools, bends), important structures, attributes of the bank and near bank area, and the location of all areas sampled. The map should also include an arrow in the direction of flow and an arrow depicting north.

2. A composite sample is collected from stable stream macroinvertebrate habitats in the sample reach (e.g., riffles, shoreline, aquatic vegetation, leaf pack, root wads, and snags). Each composite sample will consist of collecting 20 individual jab/kick samples apportioned among the stable stream habitats, with a minimum of 2 samples per habitat. Each available habitat is sampled in approximate proportion to their availability in the reach. For example, if a sampling reach is composed of 10 percent riffles, 40 percent pools with vegetation, and 50 percent runs with over hanging banks, 2 samples would be collected from the riffles, 8 from the pools and 10 from the runs. A minimum of two jabs or kicks should be collected from each available habitat type. Habitat types contributing less than 5 percent of stable habitat in the reach should not be sampled. In this case, allocate the remaining jabs proportionately among the predominant substrates. Record the number of jabs and kicks taken in each habitat type in the comments on the Field Data Recording Form (Figure 7.19.1).

3. Sampling begins at the downstream end of the reach and proceeds upstream. Each “jab” sample consists of forcefully thrusting the net into the productive habitat for a linear distance of 1 m. Kick samples should be collected from snag or riffle habitats. A “kick” is a stationary sample taken by positioning the net and disturbing the substrate for a distance of 1 m upstream of the net.

4. All 20 jabs/kicks which are collected from the multiple habitats will be composited into a single homogeneous sample. After every three individual jab/kick samples, more often if necessary, place the sample in a sieve bucket and wash the collected material by running

clean stream water through the net two to three times. Remove large debris after rinsing and inspecting it for organisms; place any organisms found into the sample container. Do not spend time inspecting small debris in the field.

5. Transfer the sample from the sieve bucket into the sample container. Once all the individual samples are composited in the sample container, decant excess water from the container and preserve in enough 95 % ethanol to cover the sample. (Note: Forceps may be needed to remove organisms from the net.)

6. Place a Nalgene Polypaper label in the sample container and label the outside of the container with black permanent marker. Both labels should contain the station identification number and description, the field number, date and time of collection, and the collector(s) name. The outside of the container should also contain the words: “preservative: 95% ethanol. ”If more than one container is used for a sample, each container should contain all the information for the sample and should be numbered 1 of 2, 2 of 2, etc.

7. Record each sample on the Macroinvertebrate Field Sample Log Form (Figure 7.19.2). Include information such as field number, station identification and description, date and time, and number of containers.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

7.20 STANDARD OPERATING PROCEDURE FOR LABORATORY PROCESSING OF MACROINVERTEBRATE SAMPLES

Summary

Macroinvertebrate samples collected in the field by either the single or multi-habitat method are best processed in the laboratory under controlled conditions. Aspects of laboratory sample processing include washing, rinsing, sub-sampling, sorting, identification, and enumeration of organisms.

The following protocol describes a method to sub-sample macroinvertebrates collected from a site. In cases where the sample contains large numbers of organisms, sub-sampling reduces the effort required for sorting and identification. The following protocol is based on a 300 organism sub-sample, but it can be used for any size sub-sample (100, 200, 500, etc.).

Equipment list

___ Laboratory sample log in forms (Figure 7.20.1)
___ Laboratory bench sheets for sorting and identification (7.20.2)
___ Sorting Pans (surface area of pan should be divided into grids of equal size for picking)
___ Forceps (both fine tipped, medium tipped and curved)
___ Dissecting Probes and Needles
___ Watch Glasses
___ Dissecting Scope (9X to 110X for final IDs)
___ Dissecting Scope (7X to 30X to aid in sorting)
___ Compound Microscope (4X, l0X, 40X, and 100X oil objectives andphase contrast optics)
___ Specimen Vials (assorted sizes of 1, 2, and 4 drams and larger with screw cap vials for voucher specimens)
___ Squeeze bottles (1 liter for 70% ethanol)
___ Eyedroppers
___ Tally counter
___ Hot plate
___ Microscopes slides
___ Microscope coverslips 1 oz. Round
___ Magnifying lens with light source for picking samples
___ Taxonomic keys
___ 70% Ethanol
___ Euparol and/or CMC 10 mounting media
___ Potassium Hydroxide (KOH) 10% by volume
___ Illuminator compatible with dissecting scope
___ Deck of numbered cards

Procedures

1. Sample Custody/Login In

In order to ensure proper sample custody, upon transfer and receipt by laboratory personnel, record all samples on the laboratory sample log in form (Figure 7.20.1). Include the date received and all information from the sample container label. If more than one container was used, record the number of containers per sample. All samples should be sorted in the same laboratory to enhance quality control.

2. Washing and Preparing the Sample for Sorting

Thoroughly rinse the sample in a 500 µm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algae, or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms. This will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for a given sample should be combined at this time. Gently mix the sample by hand while rinsing to make the entire sample homogeneous.

After washing, spread the sample evenly across a pan marked with numbered grids approximately 6 cm x 6 cm. Along the sides and top of the gridded pan, line up numbered specimen vials, which will hold the sorted organisms. Start with vials 1-15 set up and have vials 16-30 available, if needed. If the sample is to be identified that day, these jars can contain water. If it is towards the end of the day and they will not be identified in the next twelve hours the jars should contain 70 percent ethanol.

3. Sample Sorting and Counting

Using a deck of cards that contains numbers corresponding to the numbered grids in the pan, draw a card to select a grid within the gridded pan. This is done to make sure a random sampling is carried out. Begin picking organisms from that square and placing them in the numbered vials. Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organism is considered to be in the grid containing most of its body. Each numbered vial should contain one taxon of organisms. Use a tally counter to keep track of the total number of organisms. The tally counters can also be used to keep track of specific taxa (i.e., scuds or corixids) that may be in high abundance. When all organisms have been removed from the selected grid, draw another card and remove all the organisms from that grid in the same manner. If new taxa are found, place them in the next empty vial. Continue this process of drawing cards and picking grids. After 10 grids have been picked, determine the average number of organisms per grid and determine approximately how many total grids will be picked to reach 300 organisms. When approaching that number of grids, monitor the total count of organisms. A sample should not be stopped in the middle of picking a grid, so stop on a grid that will give a number of 300 organisms or more. This is done to eliminate any bias as to which organisms would be picked in the last grid. Rarely will the final count be exactly 300 organisms. Note on the bench data sheet how many grids were picked to get the final count. Save the remaining unsorted sample debris residue in a separate container labeled “sample residue”; this container should include the original sample label.

On the laboratory bench data sheet (Figure 7.20.2) write down the tentative identifications and total numbers of organisms for each vial. Examine vials under a 10X dissecting scope to count organisms and ensure that all organisms in a jar are of the same taxon. Do not try and separate taxa that are hard to differentiate, this will be done under higher power during the final identification. Once all vials have been recorded on the bench sheet, place screw tops on the vials, place the vials and bench sheet in to a designated tray and bring it over to the final identification station.

After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

4. Sample Identification

Final organism identifications should be done to the lowest taxonomic level practicable (genus/species preferred). In order to provide accurate taxonomic identification, midge (Chironomidae) larvae and pupae will be mounted on slides in an appropriate medium (e.g., Euperal, CMC-10); slides will be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled. All slides should be archived so further levels of identification can be done at a later date. Each taxon found in a sample is recorded and enumerated on the laboratory bench sheet (Figure 7.20.2). Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

Record the identity and number of organisms in each taxonomic group on the laboratory bench sheet. Also, record the life stage of the organisms and the taxonomist’s initials. After each taxon is identified, the organisms will be placed in a container. A label with the site number, location, date of the sample, and taxonomic identification should also be placed in the container.

5. Sample Vouchers and Storage

In order to ensure accuracy and precision it is recommended that a voucher collection be established for each set of samples which are enumerated and identified by a specific laboratory. A voucher collection is established by extracting individual specimens of each taxon from the sample collection. These individuals will be placed in specimen vials and tightly capped. A label that includes site, date, taxon, and identifying taxonomist will be place inside the vial. Slides that are to be included in the voucher collection must be initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.

For archiving samples, specimen vials (grouped by voucher collection station and date) are placed in jars with a small amount of denatured 70 percent ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vials takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (denatured 70 percent ethanol). Voucher collections will be cataloged and placed in the North Dakota River and Stream Macroinvertebrate Collection located at Valley City State University by Dr. Andre DeLorme, Ph.D.

North Dakota Department of Health
Division of Water Quality
Macroinvertebrate Laboratory Bench Data Sheet

Site: _________**Sample #:** ________ **Date sampled:**___________

No. of Squares picked; _____ Pickers: ______DateID:_______

Jar #	Phylum/ Order	Family	Genus Species	Final Count	Life Stage	Notes
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Figure 7.20.2. Macroinvertebrate Laboratory Bench Data Sheet.

Appendix B

Landscape Index Development Procedure

Landscape Index Development

The Landscape Index (LSI) was developed to add a broader watershed landuse component to our estimate of human disturbance and refine our development of biological indicators. The habitat assessments from the Rapid Bioassessment Protocol (RBP) provided local, site specific disturbance, but did not encompass much beyond what was visible at a site. Combining these two indices allowed for a more holistic approach to determining human disturbance.

Methods

The LSI was developed using the Analytical Tools Interface for Landscape Assessments (ATtILA, Version 3.0) in ArcView 3.2. This ArcView extension required six specific datasets to provide data on potential landuse metrics (Ebert *et al.* 2001) (Table 1). Initial investigation evaluated whether delineating watershed boundaries within 3 km of a sample site or using 3 km circles centered at the site were different in determining landuse metrics. The sample area was all 12-digit hydrologic unit code (HUC) watersheds that had been delineated within the border of North Dakota as of 2004. Those 12-digit HUC watersheds that were only partially inside the border were not used in this analysis because the landuse coverage was available only for North Dakota. Each 12-digit HUC (n = 304) had a test site added at the outlet point. The results indicated both methods yielded similar information (Table 2). Since delineating watershed boundaries for site evaluation required more effort, 3 km circular buffers were used to analyze potential metrics for the LSI. A total of 46 metrics were considered for use in the LSI. Metrics were evaluated by the overall range of values, colinearity with other metrics (through a correlation matrix) and best professional judgment. Metrics were eliminated with narrow value ranges and those selected had moderate to low correlation.

Results and Discussion

A total of 6 metrics were selected for the final LSI (Table 3; abbreviations for metrics are listed in Table 2). They represented erosion potentials, landuse nearest to stream edge, road density (which also is a surrogate to population) and nutrient loading. Metrics had broad ranges (Table 3) and limited correlation (did not exceed r = 0.60) (Table 4).

Erosion potential metrics (AGPSL3 and AGCSL3) were included for both cropland and pastureland recognizing that the eastern part of North Dakota is dominated by row crop agriculture and western North Dakota is dominated by cattle grazing. A slope of 3% is the threshold determined at which soil erosion occurs (USDA 1951). Increased soil erosion could lead to higher total suspended solids and increased sedimentation. Metrics addressing cropland and grasslands nearest the stream (RAGC30 and RNG30) were used to determine runoff problems. Cropland provides little buffer to overland flow whereas grassland provides greater retention and absorption. Roadways could impact streams through increased runoff and sediment. Increased road density (RDDENS) also indicated areas of higher population. Runoff from these areas could carry lawn fertilizer, automobile fluids/oils and other harmful household chemicals to the stream. Nutrient loading was addressed by the phosphorus loading metric (P_LOAD). This was an estimate of nonpoint source phosphorus coming off all the surrounding land within the 3 km buffer. Estimates were based on literature export coefficients (Reckhow *et al.* 1980). Increased levels of phosphorus could lead to eutrification of a stream and decreased oxygen levels. All of the metrics included in the LSI provided a broader look at human impacts that could potentially affect the biological community.

Literature Cited

Ebert, D. W., T. G. Wade, J. E. Harrison, and D. H. Yankee. 2001. Analytical Tools Interface for Landscape Assessment (ATtILA) Quick Start Guide Version 3.0. Draft. http://www.epa.gov/nerlesd1/land-sci/oregon/attila/user_guide.html

Reckhow, K.H., Beaulac, M. N., and Simpson, J. T. 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients. USEPA 440/5-80-011. Washington, DC: Office of Water Regulations and Standards, U.S. Environmental Protection Agency.

U.S. Department of Agriculture. 1951. Soil Survey Manual. Agricultural Handbook 18. Washington, DC: U.S. Department of Agriculture. 503pp.

Table 1. Data Input and Sources for the Analytical Tools Interface for Landscape Assessments (ATtILA) Used to Develop the Landscape Index (LSI).

	Dataset	Source
1	Landuse/Land cover	National Agricultural Statistic Services, 2003 data
2	Elevation/Slope	United States Geological Survey (USGS), Digital Elevation Map (DEM)
3	Streams	USGS, National Hydrography Dataset (NHD)
4	Roads	North Dakota Department of Transportation
5	Population	U.S. Census Bureau, 2000 data
6	Precipitation	North Dakota State Climatologist, North Dakota Agricultural Weather Network (NDAWN), Average precipitation 1971-2000

Table 2. Pearson Correlation Coefficient (r) of Landscape Index (LSI) Metrics Comparing Watershed Boundaries Within 3 km to 3 km Circular Buffers of Sample Sites. (All are significant at $p<0.0001$.)

Metrics	Abbreviation	r
Percentage of pasture land on a slope of > 3%	AGPSL3	0.95
Percentage of crop land on a slope of > 3%	AGCSL3	0.88
Percentage of crop land within 30M of the stream	RAGC30	0.95
Percentage of grasslands within 30M of the stream	RNG30	0.88
Road density	RDDENS	0.82
Phosphorus loading	P_LOAD	0.93

Table 3. Range of Values for the Landscape Index (LSI) Metrics.

Metrics	Human disturbance greatest at this level	Range	
AGPSL3	Higher	0%	89.4%
AGCSL3	Higher	0%	43.0%
RAGC30	Higher	0%	92.7%
RNG30	Lower	0%	63.3%
RDDENS	Higher	0 km/buffered area	11.3 km/buffered area
P_LOAD	Higher	0.4 kg/ha/yr	1.5 kg/ha/yr

Table 4. Pearson Correlation Matrix of the Landscape Index (LSI) Metrics.

	AGPSL3	AGCSL3	RAGC30	RNG30	RDDENS	P_LOAD
AGPSL3	1.00					
AGCSL3	0.02	1.00				
RAGC30	-0.60	0.18	1.00			
RNG30	-0.34	0.07	0.16	1.00		
RDDENS	-0.15	-0.08	-0.01	0.02	1.00	
P_LOAD	-0.12	-0.12	0.42	-0.35	-0.02	1.00

Appendix C

List of Metrics Evaluated

Percent Abundance
Amphipoda
Chironomidae
Coleoptera
CricotopusChironomus/
Chironomidae
Chironomidae
Diptera
Ephemeroptera
Plecoptera
Trichoptera
EPT
Gastropoda
Non-Insect
Odonata
Oligochaeta
Burrower
Climber
Clinger
Sprawler
Swimmer
Collector
Filterer
Predator
Scraper
Shredder
Univoltine
Multivoltine
Dominant taxa
Baetidae/Ephemeroptera
Hydropsychidae/EPT
Hydropsychidae/Trichoptera
Intolerant
Tolerant

Number of Taxa
Burrower
Climber
Clinger
Sprawler
Swimmer
Collector
Filterer
Predator
Scraper
Collector
Filterer
Predator
Shredder
Chironomidae
Coleoptera
Diptera
Ephemeroptera
Plecoptera
Trichoptera
EPT
Oligochaeta
Total
Intolerant
Tolerant

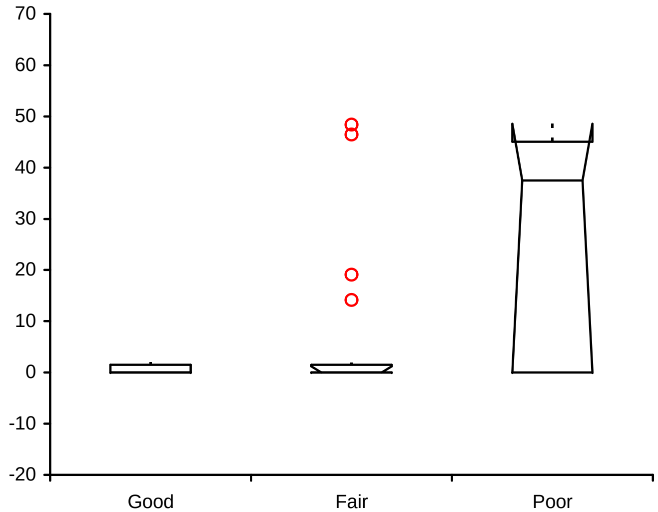
Index
Shannon-Weiner_e
Hilsenhoff Biotic
Beck Biotic
Simpson’s
Margalef’s

Appendix D

Box-Whisker Plots

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Amphipods by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



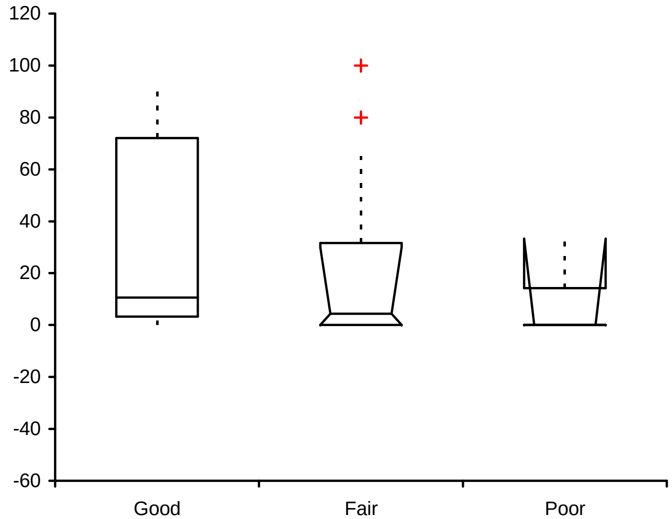
AmphPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	0.510	1.0204	0.5102	-0.690 to 1.711	0.000	1.531	- to -
Fair	19	6.969	15.1675	3.4797	0.935 to 13.003	0.000	1.541	0.000 to 1.176
Poor	5	26.215	24.2605	10.8496	3.086 to 49.345	37.500	45.062	0.000 to 48.515

analysed with: Analyse-it + General 1.67

Test **Comparative descriptives**

Percent Baetidae/ Percent Ephemeroptera by HDI rating

Performed by Neil Haugerud **Date** 26 October 2004



et2EphPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	27.932	42.3124	21.1562	-21.857 to 77.720	10.625	68.869	- to -
Fair	19	22.215	30.4893	6.9947	10.086 to 34.344	4.348	31.667	0.000 to 30.000
Poor	5	9.524	14.6772	6.5638	-4.469 to 23.517	0.000	14.286	0.000 to 33.333

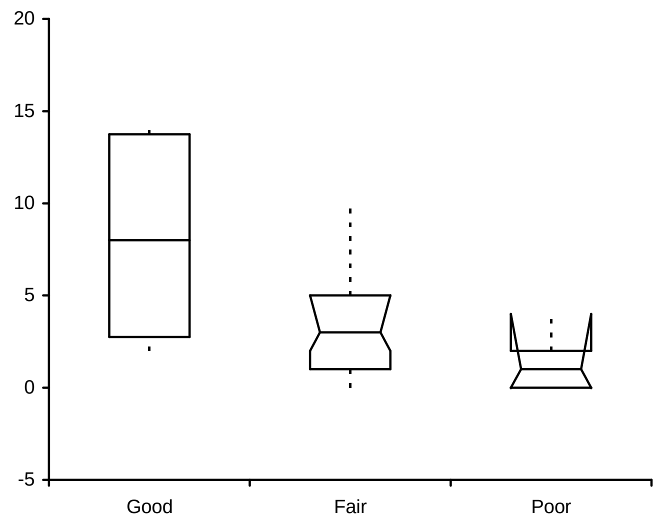
analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Beck Biotic Index by HDI rating

Performed by Neil Haugerud

Date 26 October 2004



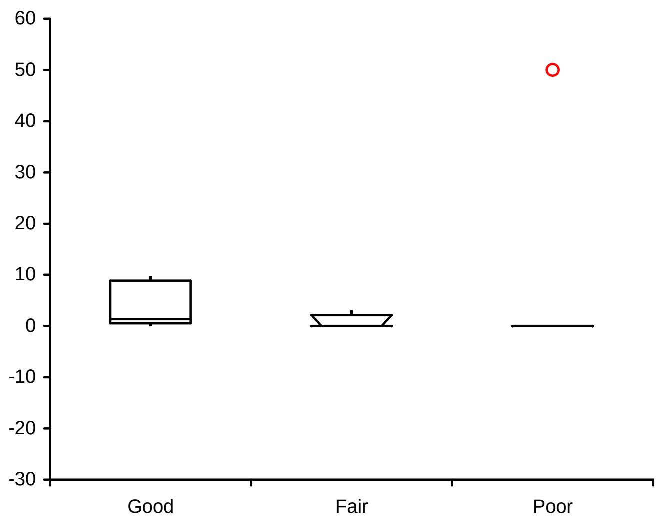
BeckBI by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	8.000	6.3770	3.1885	0.496 to 15.504	8.000	11.000	- to -
Fair	19	3.421	3.1325	0.7187	2.175 to 4.667	3.000	4.000	2.000 to 5.000
Poor	5	1.400	1.6733	0.7483	-0.195 to 2.995	1.000	2.000	0.000 to 4.000

analysed with: Analyse-it + General 1.62

Test | **Comparative descriptives**

Percent Bivalvia by HDI rating

Performed by Neil Haugerud **Date** 26 October 2004



BivalPct by Index rating	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Good	4	3.457	5.1725	2.5863	-4.773 to 11.688	1.359	8.335	- to -
Fair	19	0.985	1.2196	0.2798	0.398 to 1.573	0.000	2.119	0.000 to 2.198
Poor	5	10.000	22.3607	10.0000	-17.764 to 37.764	0.000	0.000	- to -

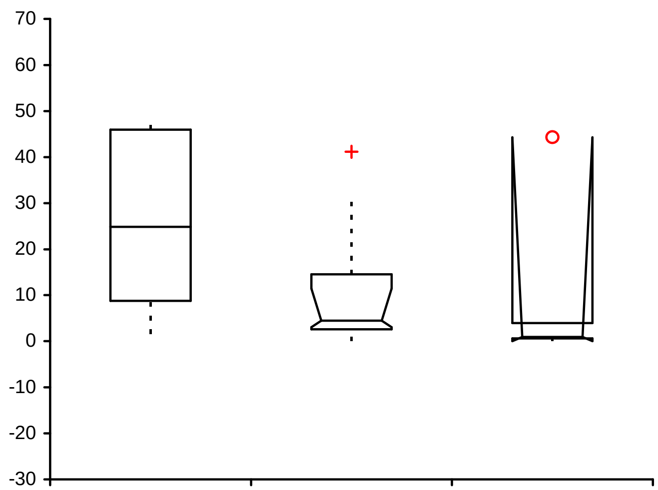
analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Percent Burrowers by HDI rating

Performed by | Neil Haugerud

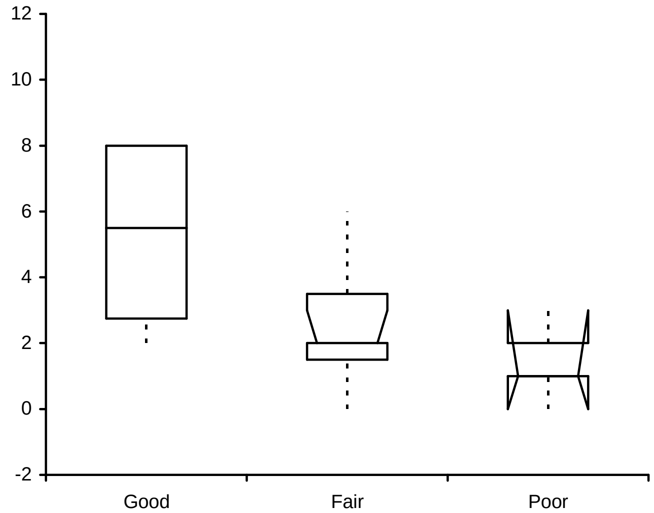
Date | 26 October 2004



BrrwrPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	24.931	22.1323	11.0662	-1.112 to 50.974	24.831	37.150	- to -
Fair	19	10.059	11.5971	2.6606	5.445 to 14.672	4.444	11.932	3.061 to 11.429
Poor	5	9.973	19.2599	8.6133	-8.389 to 28.336	0.971	3.343	0.000 to 44.318

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**		
	Burrower Taxa by HDI rating		
Performed by	Neil Haugerud	**Date**	26 October 2004



BrrwrTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	5.250	3.2016	1.6008	1.483 to 9.017	5.500	5.250	- to -
Fair	19	2.421	1.8048	0.4140	1.703 to 3.139	2.000	2.000	2.000 to 3.000
Poor	5	1.400	1.1402	0.5099	0.313 to 2.487	1.000	1.000	0.000 to 3.000

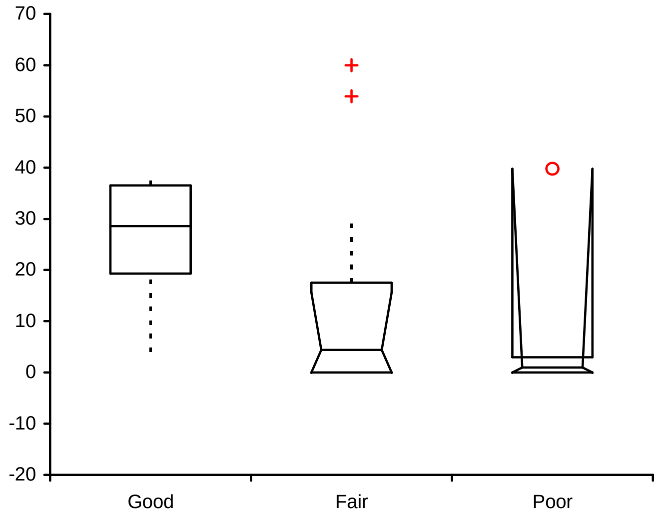
analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Percent Chironomidae by HDI rating

Performed by Neil Haugerud

Date 26 October 2004



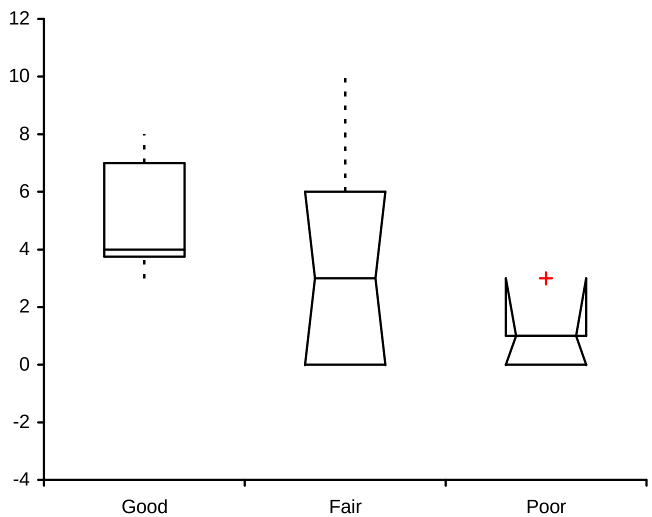
ChiroPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	24.736	14.9012	7.4506	7.202 to 42.270	28.610	17.222	- to -
Fair	19	12.850	18.3444	4.2085	5.552 to 20.147	4.396	17.506	0.000 to 15.625
Poor	5	8.743	17.3886	7.7764	-7.835 to 25.321	0.971	2.970	0.000 to 39.773

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Chironomidae Taxa by HDI rating

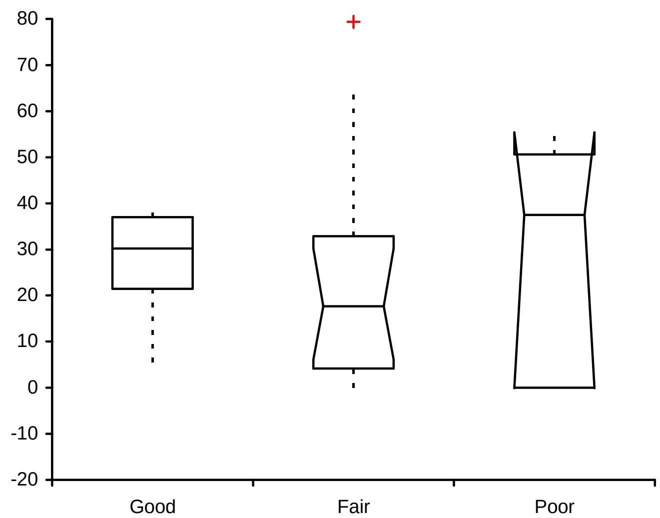
Performed by Neil Haugerud **Date** 26 October 2004



ChiroTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	4.750	2.2174	1.1087	2.141 to 7.359	4.000	3.250	- to -
Fair	19	3.105	3.3149	0.7605	1.787 to 4.424	3.000	6.000	0.000 to 6.000
Poor	5	1.000	1.2247	0.5477	-0.168 to 2.168	1.000	1.000	0.000 to 3.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**		
	Percent Collectors by HDI rating		
Performed by	Neil Haugerud	**Date**	26 October 2004



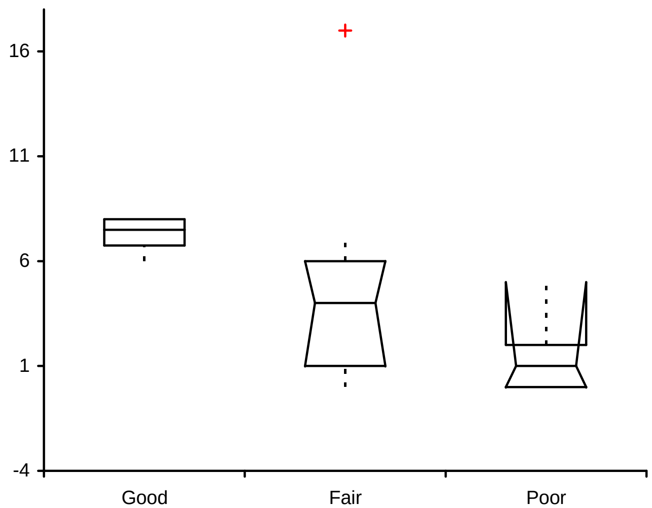
CllctPct by Index rating	n	Mean	SD	SE	90% CI of Mean	
Good	4	26.033	14.4277	7.2139	9.057	to 43.010
Fair	19	23.771	23.3539	5.3578	14.480	to 33.062
Poor	5	28.713	27.0209	12.0841	2.951	to 54.474

	Median	IQR	90% CI of Median	
Good	30.227	15.538	-	to -
Fair	17.647	28.674	6.122	to 30.208
Poor	37.500	50.617	0.000	to 55.446

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Collector Taxa by HDI rating
Performed by	Neil Haugerud

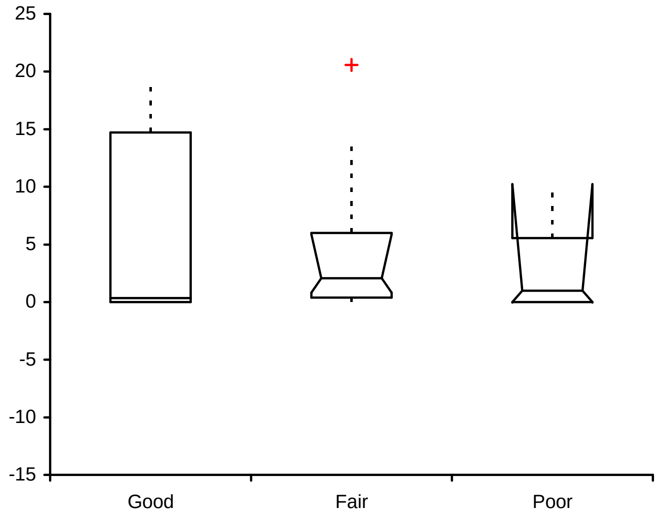
Date 26 October 2004



ClIctTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	7.250	0.9574	0.4787	6.123 to 8.377	7.500	1.250	- to -
Fair	19	4.053	4.0204	0.9223	2.453 to 5.652	4.000	5.000	1.000 to 6.000
Poor	5	1.600	2.0736	0.9274	-0.377 to 3.577	1.000	2.000	0.000 to 5.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Climbers by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004

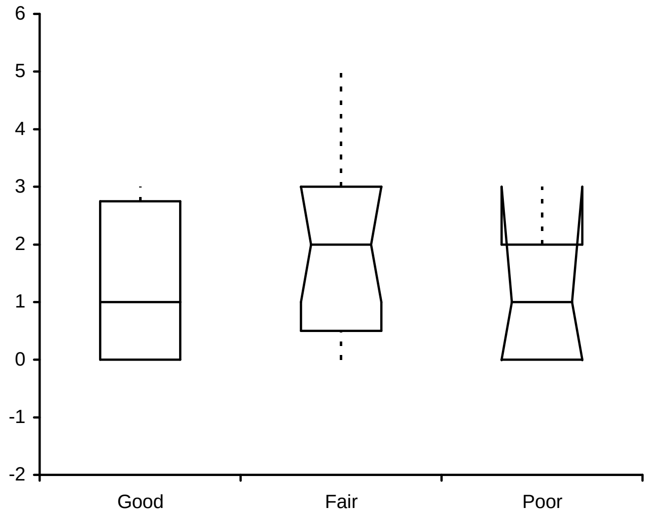


ClmbrPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	5.016	9.5862	4.7931	-6.263 to 16.296	0.339	14.710	- to -
Fair	19	4.665	5.8461	1.3412	2.339 to 6.991	2.083	5.599	0.806 to 5.882
Poor	5	3.355	4.4770	2.0022	-0.914 to 7.623	0.990	5.556	0.000 to 10.227

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Climber Taxa by HDI rating
Performed by	Neil Haugerud

Date 26 October 2004



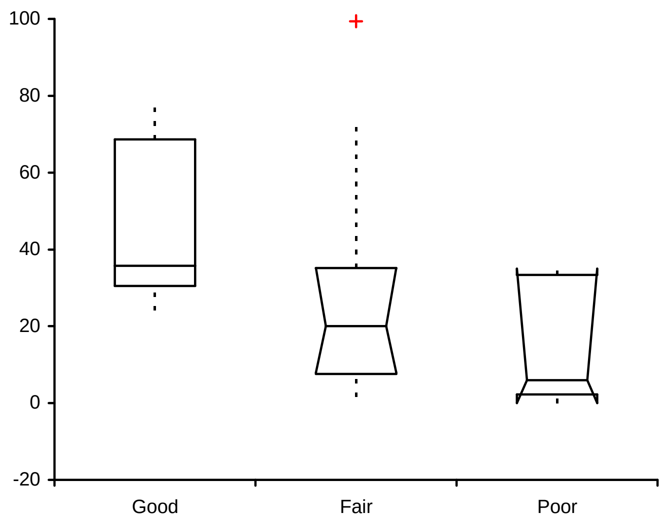
ClmbrTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	1.250	1.5000	0.7500	-0.515 to 3.015	1.000	2.750	- to -
Fair	19	1.842	1.5728	0.3608	1.216 to 2.468	2.000	2.500	1.000 to 3.000
Poor	5	1.200	1.3038	0.5831	-0.043 to 2.443	1.000	2.000	0.000 to 3.000

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Performed by | Neil Haugerud

Date | 26 October 2004



ClngrPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	43.511	24.1373	12.0687	15.109 to 71.913	35.702	38.109	- to -
Fair	19	26.651	25.0735	5.7523	16.676 to 36.626	20.000	27.610	7.937 to 35.135
Poor	5	15.309	17.3543	7.7611	-1.236 to 31.855	5.941	31.061	0.000 to 35.000

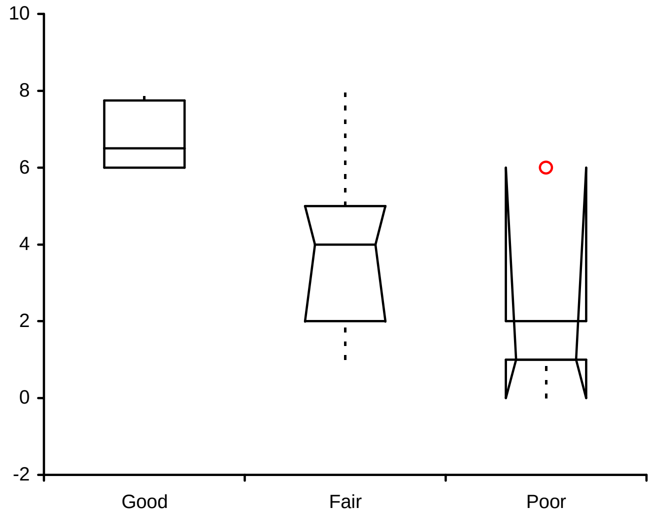
analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Clinger Taxa by HDI rating

Performed by | Neil Haugerud

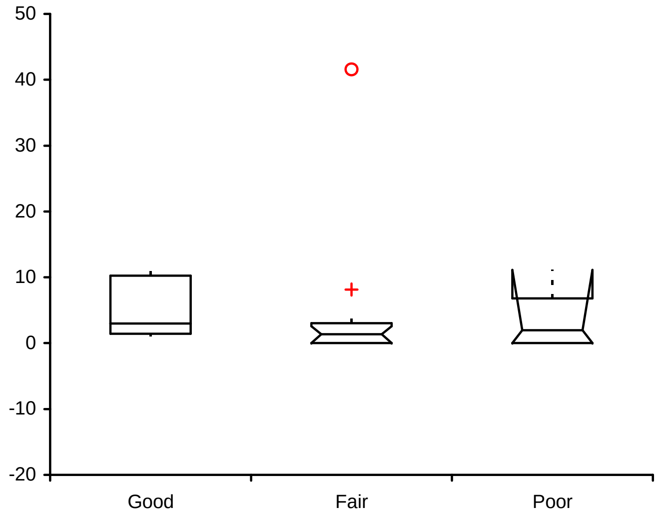
Date | 26 October 2004



ClngrTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	6.750	0.9574	0.4787	5.623 to 7.877	6.500	1.750	- to -
Fair	19	3.737	2.1040	0.4827	2.900 to 4.574	4.000	3.000	2.000 to 5.000
Poor	5	2.000	2.3452	1.0488	-0.236 to 4.236	1.000	1.000	0.000 to 6.000

analysed with: Analyse-it + General 1.67

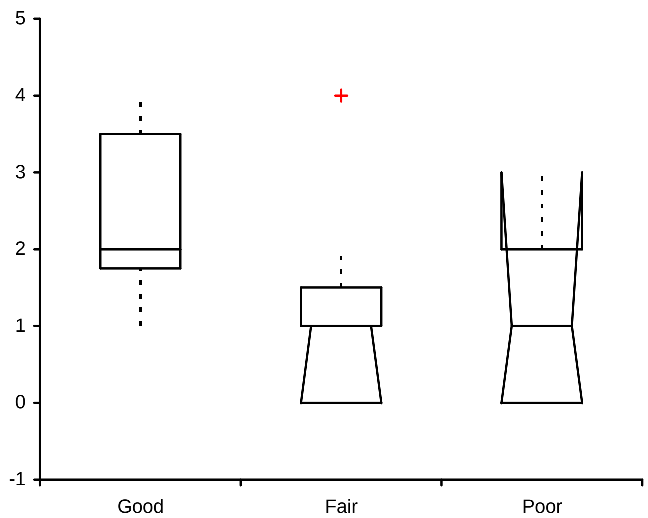
Test	**Comparative descriptives**
	Percent Coleoptera by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



ColeoPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	4.797	5.1510	2.5755	-1.265 to 10.858	2.981	8.801	- to -
Fair	19	3.845	9.3733	2.1504	0.116 to 7.574	1.351	3.043	0.000 to 2.556
Poor	5	3.982	4.8628	2.1747	-0.654 to 8.618	1.980	6.818	0.000 to 11.111

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Coleoptera taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004

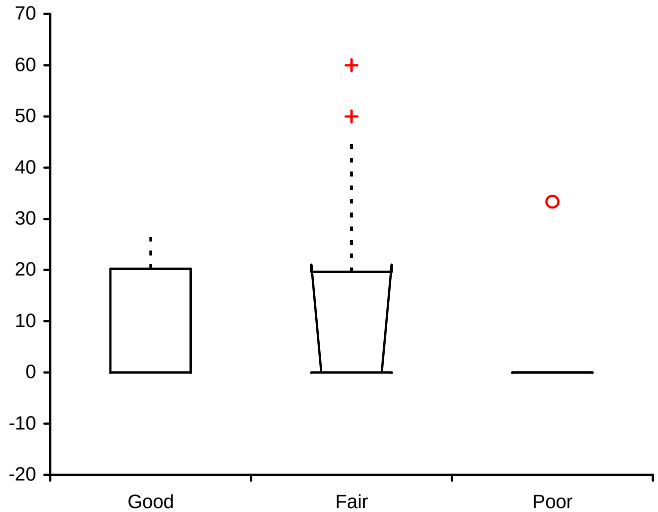


ColeoTax by Index rating	**n**	**Mean**	**SD**	**SE**	**90% CI of Mean**	**Median**	**IQR**	**90% CI of Median**
Good	4	2.250	1.2583	0.6292	0.769 to 3.731	2.000	1.750	- to -
Fair	19	1.000	1.0541	0.2418	0.581 to 1.419	1.000	1.500	0.000 to 1.000
Poor	5	1.200	1.3038	0.5831	-0.043 to 2.443	1.000	2.000	0.000 to 3.000

analysed with: Analyse-it + General 1.62

Test	**Comparative descriptives**
	CrCh2ChiPct by Index rating
Performed by	Neil Haugerud

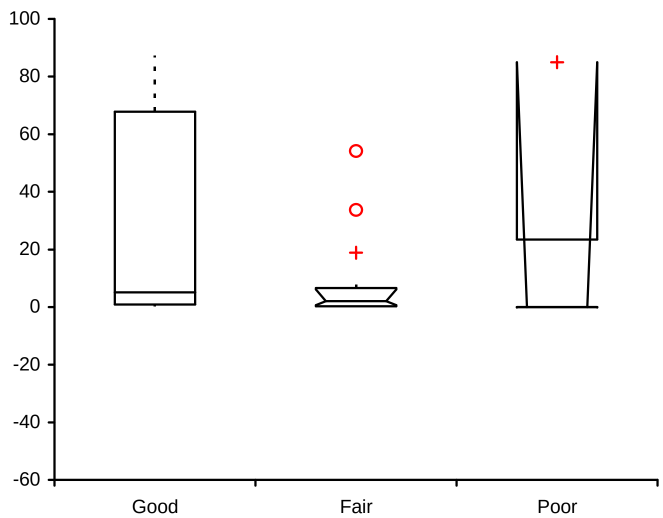
Date 26 October 2005



CrCh2ChiPct by Index rating	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Good	4	6.757	13.5135	6.7568	-14.746 to 28.260	0.000	20.270	- to -
Fair	19	12.769	19.6523	4.5086	3.296 to 22.241	0.000	19.617	0.000 to 21.053
Poor	5	6.667	14.9071	6.6667	-11.843 to 25.176	0.000	0.000	- to -

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Crustacea and Mollusca by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



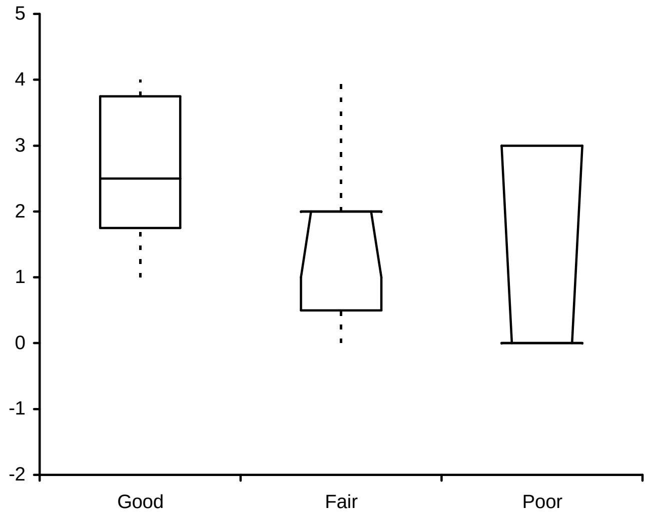
CrMolPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	24.454	42.0916	21.0458	-25.075 to 73.982	5.100	66.931	- to -
Fair	19	7.794	13.9289	3.1955	2.253 to 13.335	2.041	6.313	0.639 to 6.122
Poor	5	21.691	36.8193	16.4661	-13.412 to 56.795	0.000	23.457	0.000 to 85.000

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Crustacea and Mollusca taxa by HDI rating

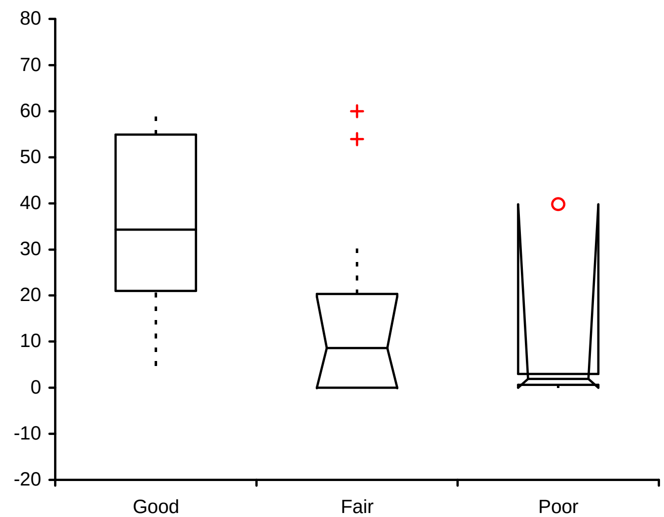
Performed by | Neil Haugerud — **Date** | 26 October 2004



CrMolTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	2.500	1.2910	0.6455	0.981 to 4.019	2.500	2.000	- to -
Fair	19	1.684	1.2933	0.2967	1.170 to 2.199	2.000	1.500	1.000 to 2.000
Poor	5	1.200	1.6432	0.7348	-0.367 to 2.767	0.000	3.000	0.000 to 3.000

analysed with: Analyse-it + General 1.67

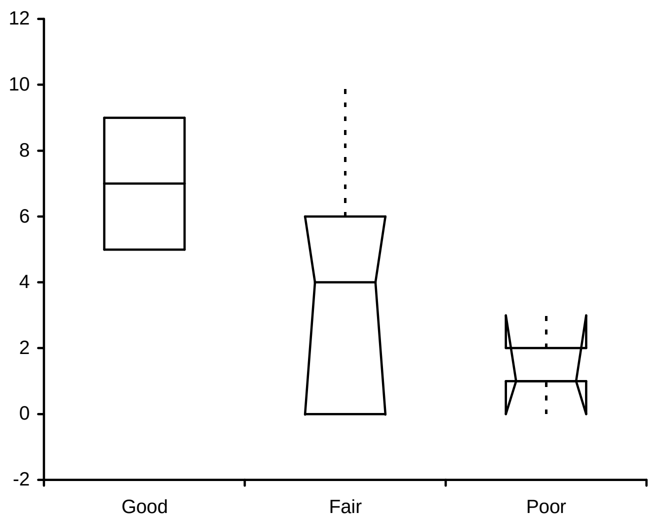
Test	**Comparative descriptives**		
	Percent Diptera by HDI rating		
Performed by	Neil Haugerud	**Date**	26 October 2004



DipPct by Index rating	**n**	**Mean**	**SD**	**SE**	**90% CI of Mean**	**Median**	**IQR**	**90% CI of Median**
Good	4	33.143	23.1684	11.5842	5.882 to 60.405	34.314	33.914	- to -
Fair	19	14.470	18.1430	4.1623	7.253 to 21.688	8.602	20.335	0.000 to 19.792
Poor	5	9.060	17.2075	7.6954	-7.345 to 25.466	1.942	2.353	0.000 to 39.773

analysed with: Analyse-it + General 1.67

Test	Comparative descriptives		
	Diptera taxa by HDI rating		
Performed by	Neil Haugerud	Date	26 October 2004

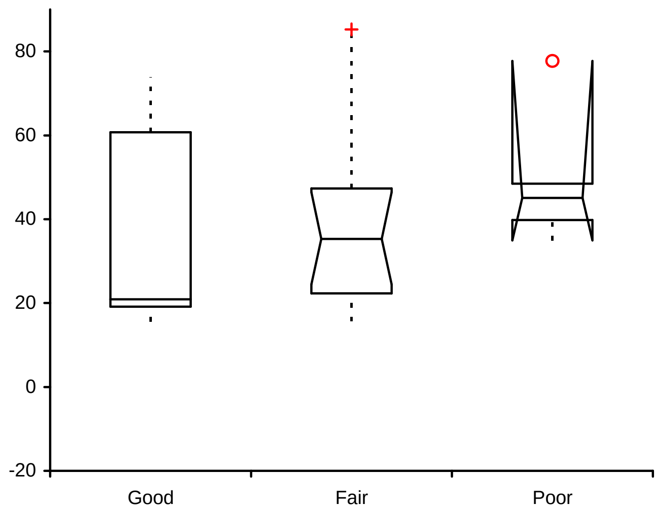


DipTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	7.000	2.3094	1.1547	4.283 to 9.717	7.000	4.000	- to -
Fair	19	3.737	3.3804	0.7755	2.392 to 5.082	4.000	6.000	0.000 to 6.000
Poor	5	1.400	1.1402	0.5099	0.313 to 2.487	1.000	1.000	0.000 to 3.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent single dominant taxa by HDI Index
Performed by	Neil Haugerud

Date 26 October 2004

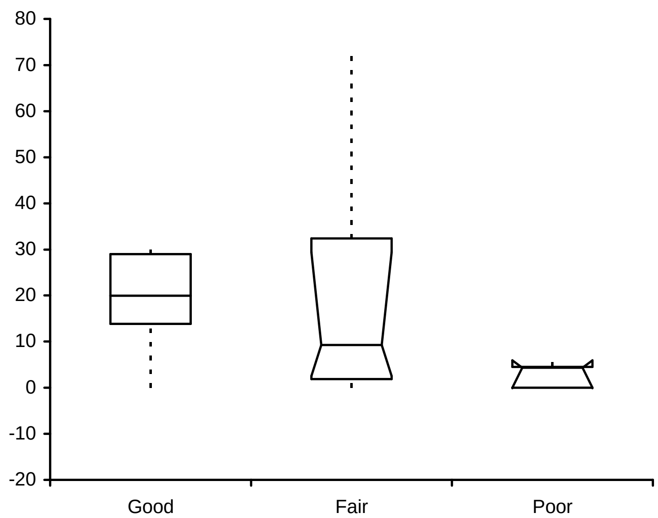


Dom01Pct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	32.801	27.4551	13.7276	0.495 to 65.106	20.884	41.554	- to -
Fair	19	39.570	21.9639	5.0389	30.833 to 48.308	35.294	24.975	24.444 to 46.429
Poor	5	49.204	16.7231	7.4788	33.260 to 65.147	45.062	8.742	35.000 to 77.670

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Ephemeroptera by HDI rating
Performed by	Neil Haugerud

Date 26 October 2004



EphemPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	17.848	13.1503	6.5751	2.374 to 33.322	19.933	15.173	- to -
Fair	19	17.712	19.5765	4.4911	9.924 to 25.500	9.275	30.487	2.556 to 29.412
Poor	5	2.961	2.7737	1.2404	0.317 to 5.606	4.321	4.545	0.000 to 5.941

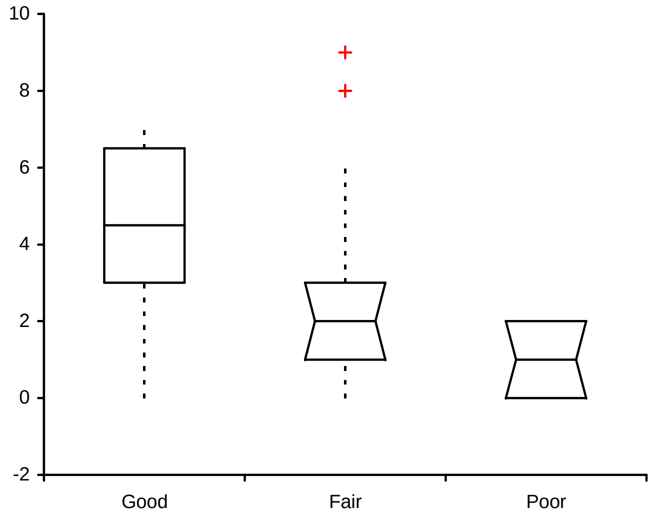
analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Ephemeroptera taxa by HDI rating

Performed by Neil Haugerud

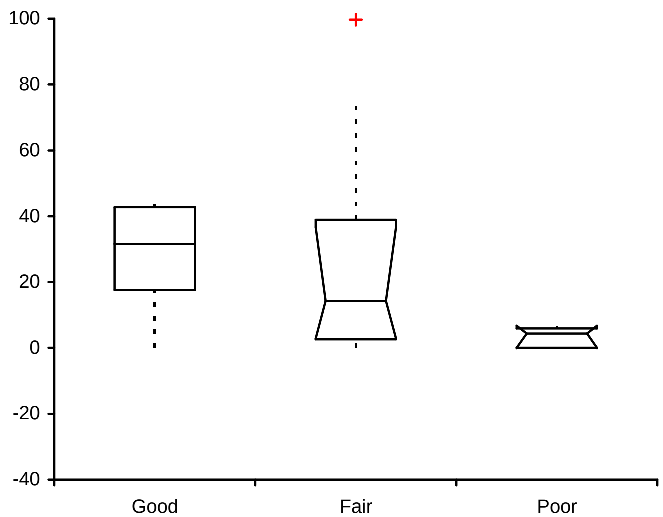
Date 26 October 2004



EphemTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	4.000	2.9439	1.4720	0.536 to 7.464	4.500	3.500	- to -
Fair	19	2.632	2.6502	0.6080	1.577 to 3.686	2.000	2.000	1.000 to 3.000
Poor	5	1.000	1.0000	0.4472	0.047 to 1.953	1.000	2.000	0.000 to 2.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Ephemeroptera, Plecoptera and Trichoptera by HID rating
Performed by	Neil Haugerud
Date	26 October 2004

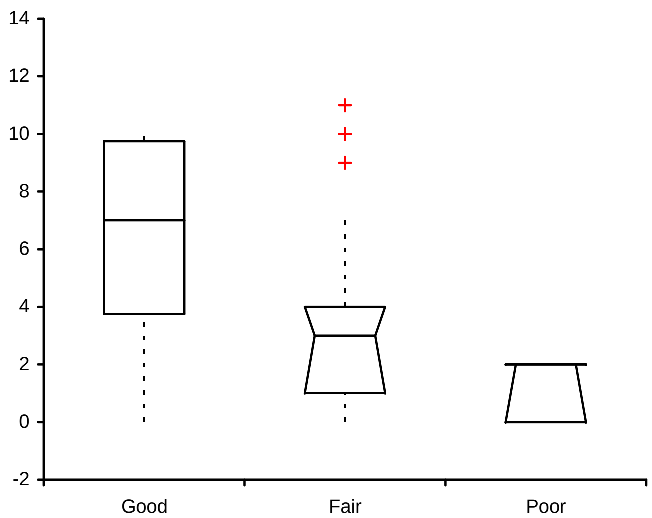


EPTPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	26.720	19.8496	9.9248	3.363 to 50.077	31.565	25.126	- to -
Fair	19	25.062	28.5463	6.5490	13.705 to 36.418	14.286	36.307	2.875 to 36.667
Poor	5	3.416	3.2444	1.4510	0.323 to 6.509	4.321	5.941	0.000 to 6.818

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Ephemeroptera, Plecoptera, and Trichoptera Taxa by HDI rating
Performed by	Neil Haugerud

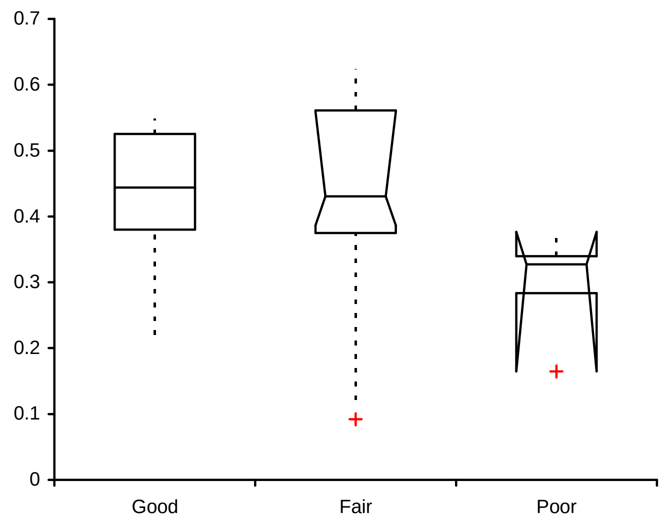
Date 26 October 2004



EPTTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	6.000	4.5461	2.2730	0.651 to 11.349	7.000	6.000	- to -
Fair	19	3.632	3.3534	0.7693	2.298 to 4.966	3.000	3.000	1.000 to 4.000
Poor	5	1.200	1.0954	0.4899	0.156 to 2.244	2.000	2.000	0.000 to 2.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Evenness by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



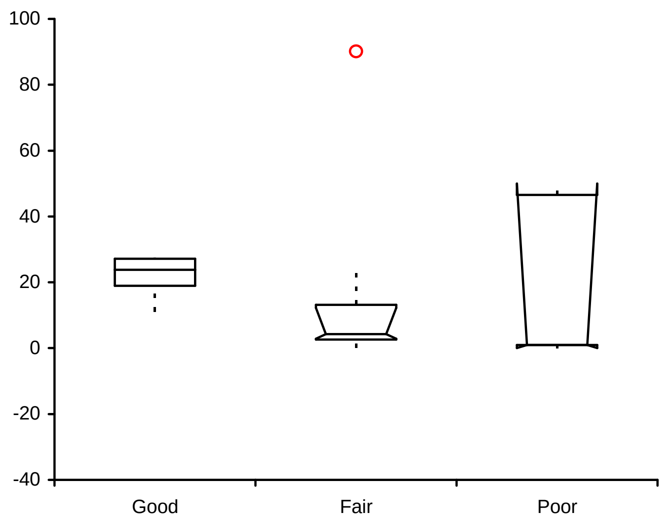
Evenness by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	0.414	0.1385	0.0692	0.251 to 0.577	0.444	0.145	- to -
Fair	19	0.423	0.1598	0.0367	0.360 to 0.487	0.431	0.187	0.386 to 0.559
Poor	5	0.298	0.0818	0.0366	0.220 to 0.376	0.327	0.056	0.165 to 0.377

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

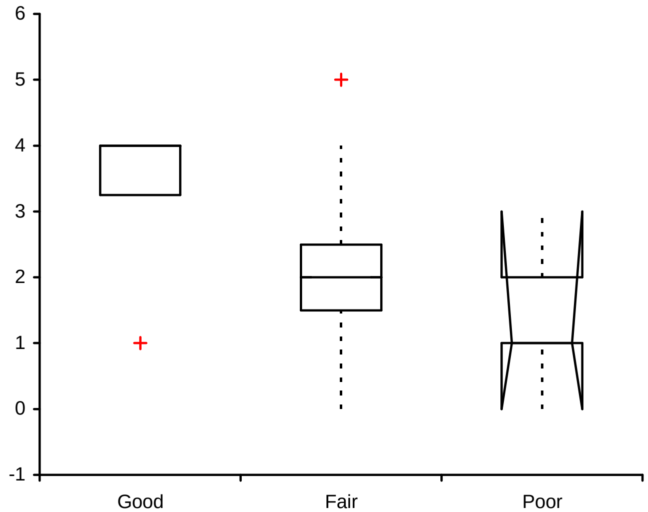
Percent Filterers by HDI rating

Performed by Neil Haugerud **Date** 26 October 2004



FiltrPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	21.582	7.4318	3.7159	12.837 to 30.326	23.832	8.239	- to -
Fair	19	12.080	20.4070	4.6817	3.961 to 20.198	4.301	10.576	2.857 to 12.245
Poor	5	19.710	26.1254	11.6836	-5.197 to 44.618	0.990	45.620	0.000 to 50.000

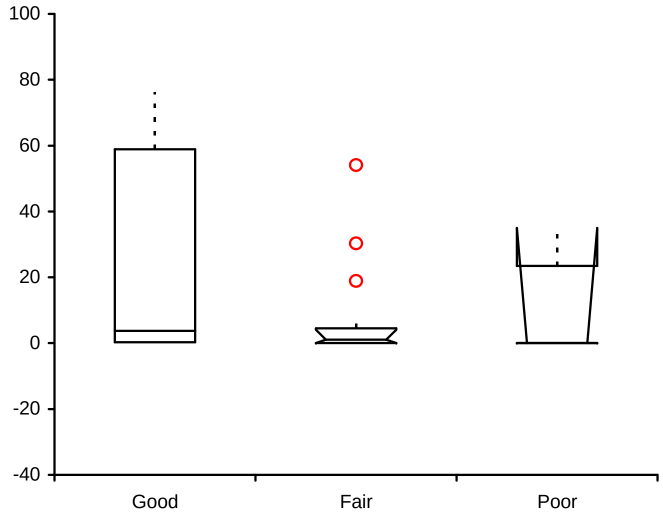
Test	**Comparative descriptives**
	Filterer Taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



FiltrTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	3.250	1.5000	0.7500	1.485 to 5.015	4.000	0.750	- to -
Fair	19	2.053	1.2236	0.2807	1.566 to 2.539	2.000	1.000	2.000 to 2.000
Poor	5	1.400	1.1402	0.5099	0.313 to 2.487	1.000	1.000	0.000 to 3.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Gastropoda by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004

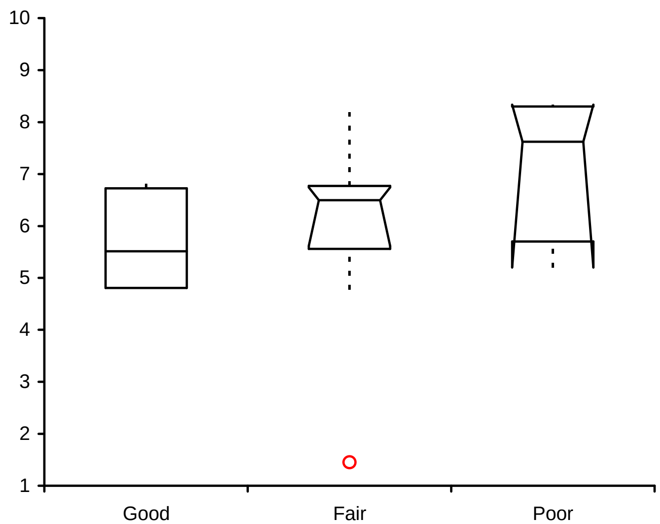


GastrPct by Index rating	n	Mean	SD	SE	90% CI of Mean
Good	4	20.996	36.9362	18.4681	-22.466 to 64.458
Fair	19	6.809	13.8176	3.1700	1.312 to 12.306
Poor	5	11.691	16.5211	7.3884	-4.060 to 27.442

	Median	IQR	90% CI of Median
Good	3.741	58.596	- to -
Fair	1.075	4.492	0.000 to 4.082
Poor	0.000	23.457	0.000 to 35.000

analysed with: Analyse-it + General 1.67

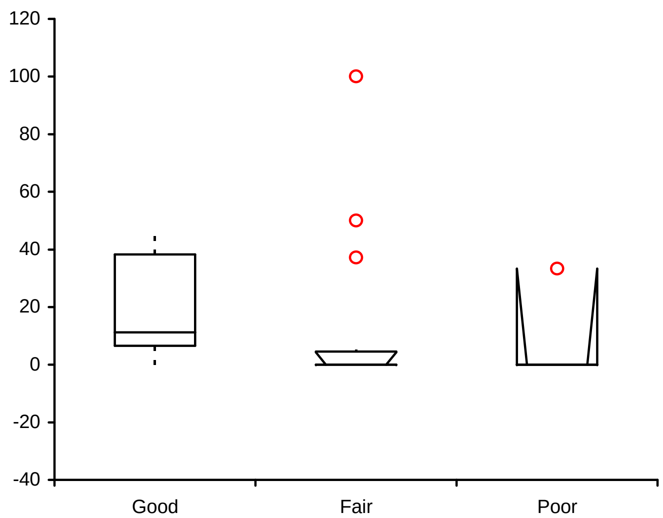
Test	**Comparative descriptives**
	Hilsenhoff Biotic Index by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



HBI by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	5.679	1.0499	0.5250	4.444 to 6.914	5.515	1.917	- to -
Fair	19	6.042	1.4294	0.3279	5.473 to 6.610	6.495	1.214	5.612 to 6.741
Poor	5	7.032	1.4788	0.6613	5.622 to 8.441	7.621	2.597	5.204 to 8.330

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Hydropsychidae/ Percent Ephemeroptera, Plecoptera and Trichoptera by Index rating
Performed by	Neil Haugerud
Date	26 October 2004

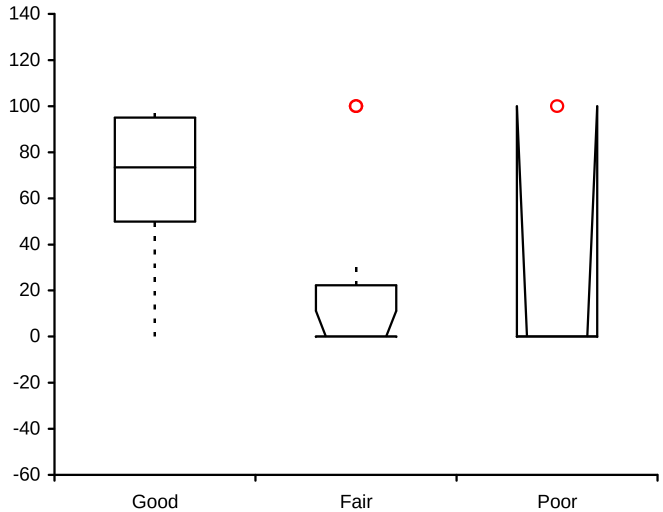


Hyd2EPTPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	17.200	20.2887	10.1444	-6.674 to 41.073	11.185	31.718	- to -
Fair	19	10.730	25.5736	5.8670	0.556 to 20.904	0.000	4.614	0.000 to 4.286
Poor	5	6.667	14.9071	6.6667	-7.546 to 20.879	0.000	0.000	0.000 to 33.333

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Hydropsychidae/ Percent Trichoptera by Index rating
Performed by	Neil Haugerud

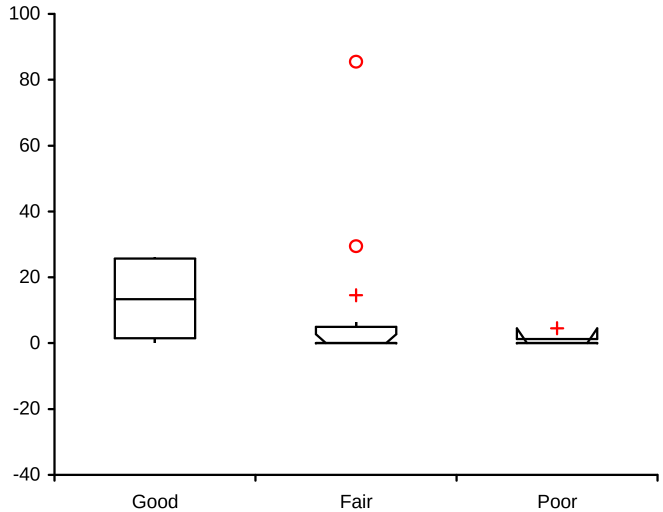
Date 26 October 2004



Hyd2TriPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	61.728	43.3683	21.6842	10.698 to 112.759	73.457	45.062	- to -
Fair	19	23.679	41.2388	9.4608	7.273 to 40.084	0.000	22.222	0.000 to 11.111
Poor	5	20.000	44.7214	20.0000	-22.637 to 62.637	0.000	0.000	0.000 to 100.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Intolerant Taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



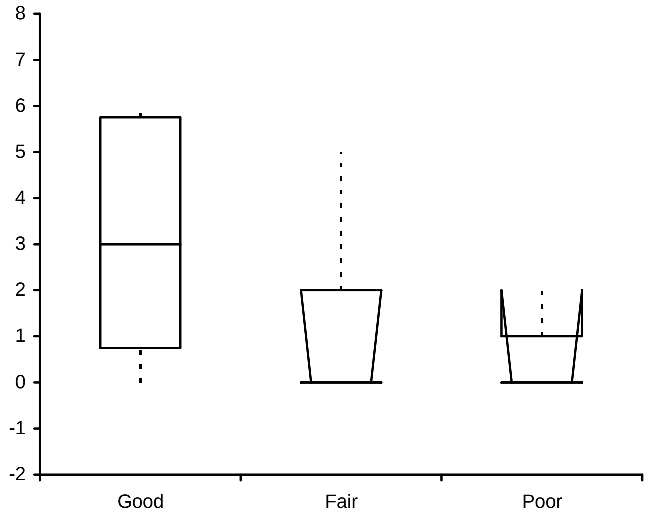
IntolPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	13.208	14.1089	7.0545	-3.394 to 29.809	13.364	24.218	- to -
Fair	19	8.049	20.1282	4.6177	0.042 to 16.057	0.000	4.980	0.000 to 2.703
Poor	5	1.156	1.9687	0.8804	-0.721 to 3.033	0.000	1.235	0.000 to 4.545

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Intolerant Taxa by HDI rating

Performed by Neil Haugerud **Date** 26 October 2004

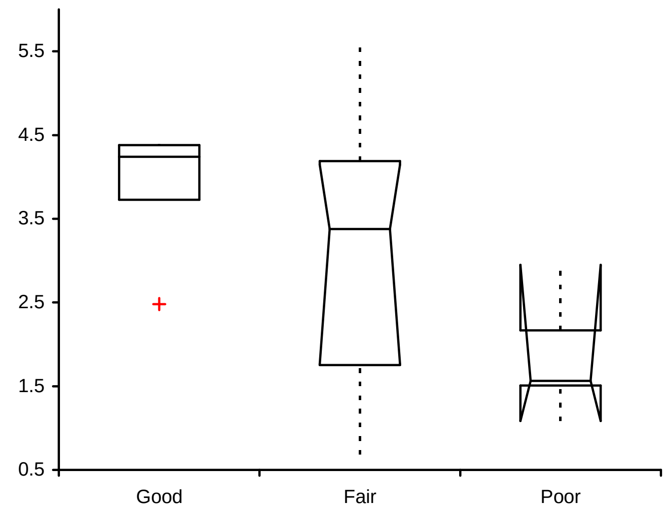


IntolTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	3.000	2.9439	1.4720	-0.464 to 6.464	3.000	5.000	- to -
Fair	19	1.105	1.5237	0.3496	0.499 to 1.711	0.000	2.000	0.000 to 2.000
Poor	5	0.600	0.8944	0.4000	-0.253 to 1.453	0.000	1.000	0.000 to 2.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Margalef's Index by Index rating
Performed by	Neil Haugerud

Date 26 October 2004

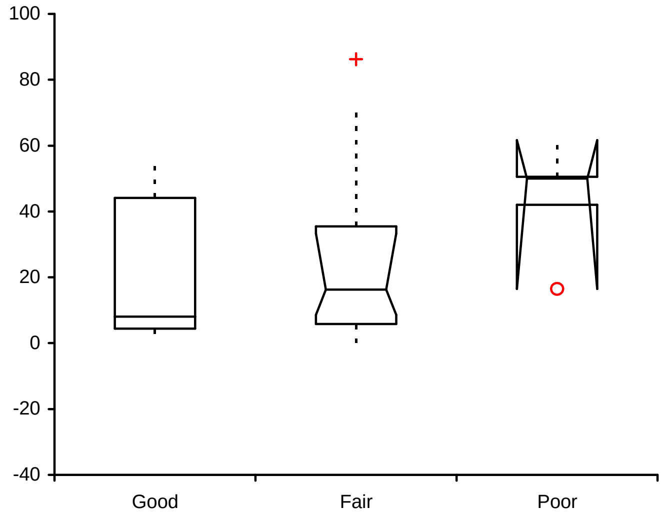


D_Mg by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	3.839	0.9114	0.4557	2.766 to 4.911	4.239	0.652	- to -
Fair	19	3.121	1.4927	0.3424	2.527 to 3.714	3.376	2.436	1.765 to 4.144
Poor	5	1.855	0.7229	0.3233	1.165 to 2.544	1.563	0.656	1.084 to 2.948

analysed with: Analyse-it + General 1.67

Test	Comparative descriptives
	Percent Multivoltine taxa by HDI rating
Performed by	Neil Haugerud

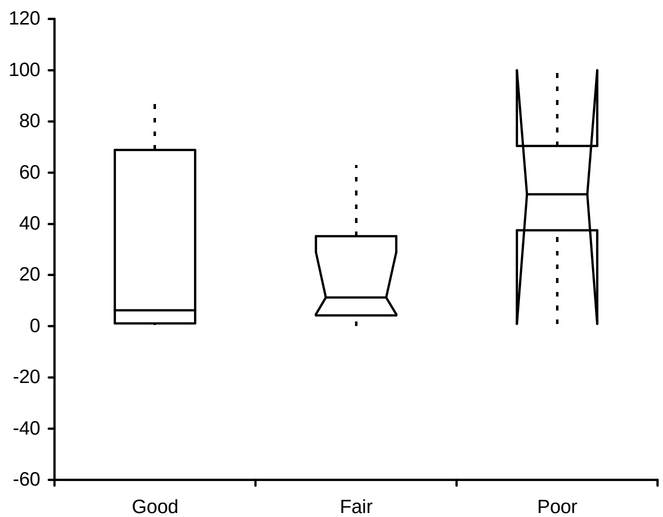
Date 26 October 2004



MltVolPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	18.481	24.6699	12.3350	-10.547 to 47.510	8.056	39.676	- to -
Fair	19	25.006	24.7908	5.6874	15.144 to 34.869	16.327	29.674	8.571 to 33.333
Poor	5	44.155	16.9718	7.5900	27.974 to 60.335	50.000	8.450	16.505 to 61.728

analysed with: Analyse-it + General 1.67

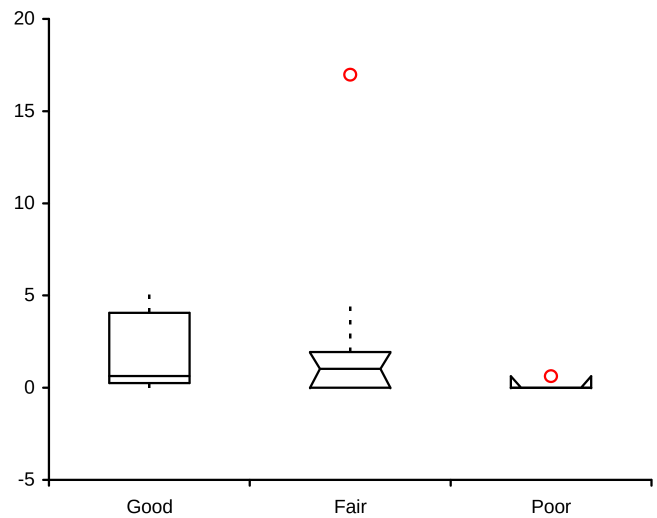
Test	**Comparative descriptives**
	Percent Noninsect by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



NonInPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	25.325	42.1249	21.0625	-24.242 to 74.893	6.290	67.704	- to -
Fair	19	21.973	22.4150	5.1424	13.056 to 30.890	11.224	30.913	4.762 to 28.889
Poor	5	52.065	36.9322	16.5166	16.855 to 87.276	51.485	32.870	0.971 to 100.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Odonata by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004

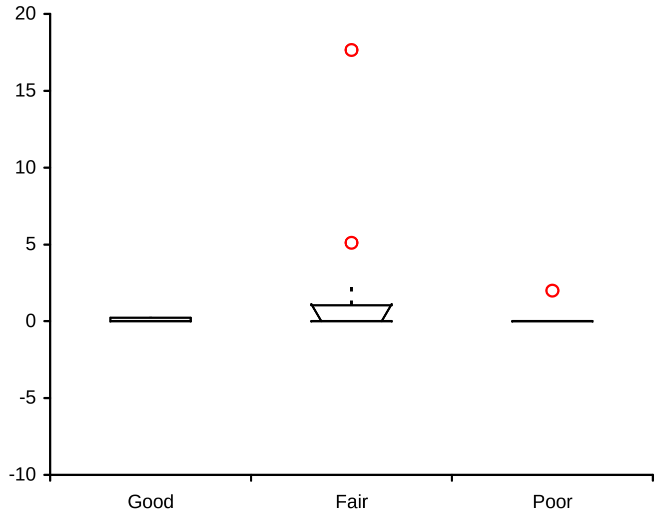


OdonPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	1.595	2.3702	1.1851	-1.194 to 4.384	0.638	3.807	- to -
Fair	19	2.016	3.9047	0.8958	0.462 to 3.569	1.020	1.933	0.000 to 1.905
Poor	5	0.123	0.2761	0.1235	-0.140 to 0.387	0.000	0.000	0.000 to 0.617

analysed with: Analyse-it + General 1.62

Test	**Comparative descriptives**
	Percent Oligocheata by HDI rating
Performed by	Neil Haugerud

Date 26 October 2004

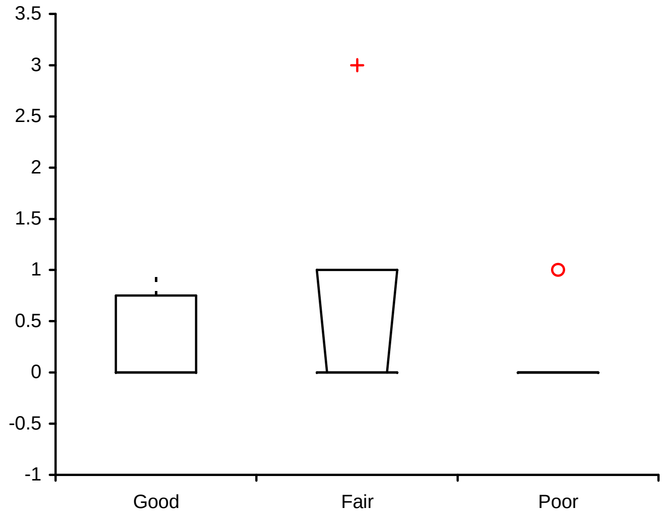


OligoPct by Index rating	**n**	**Mean**	**SD**	**SE**	**95% CI of Mean**	**Median**	**IQR**	**95% CI of Median**
Good	4	0.078	0.1563	0.0781	-0.171 to 0.327	0.000	0.234	- to -
Fair	19	1.531	4.1114	0.9432	-0.451 to 3.512	0.000	1.038	0.000 to 1.124
Poor	5	0.396	0.8856	0.3960	-0.704 to 1.496	0.000	0.000	- to -

analysed with: Analyse-it + General 1.62

Test	**Comparative descriptives**
	Oligocheate Taxa by HDI rating
Performed by	Neil Haugerud

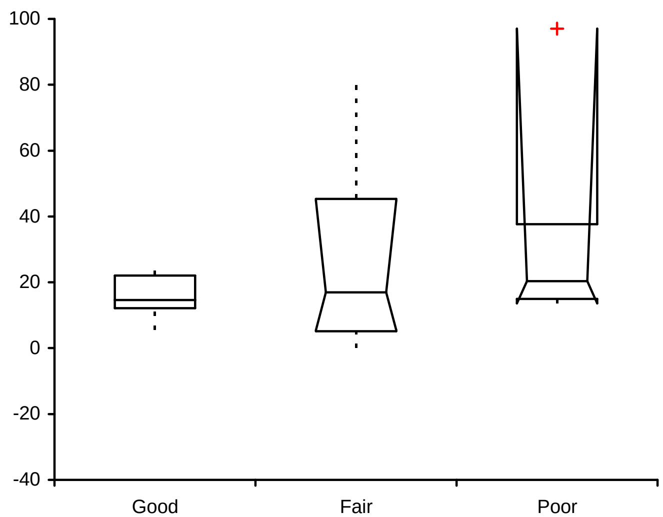
Date 10/254/2004 3:59:19 PM



OligoTax by Index rating	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Good	4	0.250	0.5000	0.2500	-0.546 to 1.046	0.000	0.750	- to -
Fair	19	0.421	0.7685	0.1763	0.051 to 0.791	0.000	1.000	0.000 to 1.000
Poor	5	0.200	0.4472	0.2000	-0.355 to 0.755	0.000	0.000	- to -

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**		
	Predator Percent by HDI rating		
Performed by	Neil Haugerud	**Date**	26 October 2004

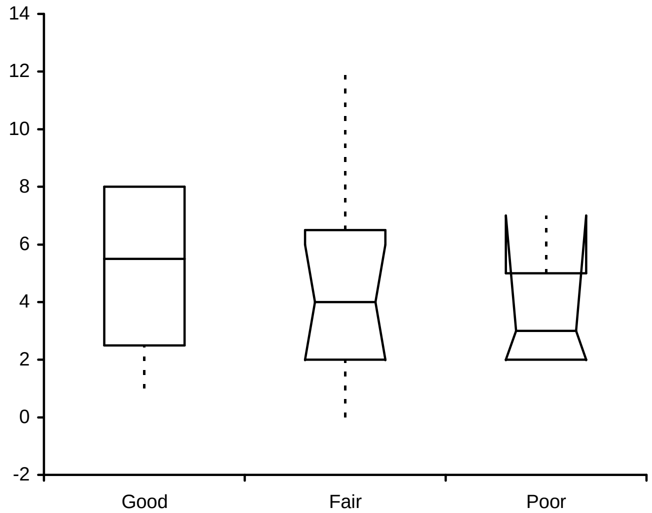


PredPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	14.812	7.7040	3.8520	5.747 to 23.877	14.643	9.952	- to -
Fair	19	26.339	24.0145	5.5093	16.785 to 35.892	16.981	40.255	5.495 to 44.792
Poor	5	36.744	35.0605	15.6795	3.317 to 70.170	20.370	22.624	13.636 to 97.087

Test | **Comparative descriptives**

Predator Taxa by HDI rating

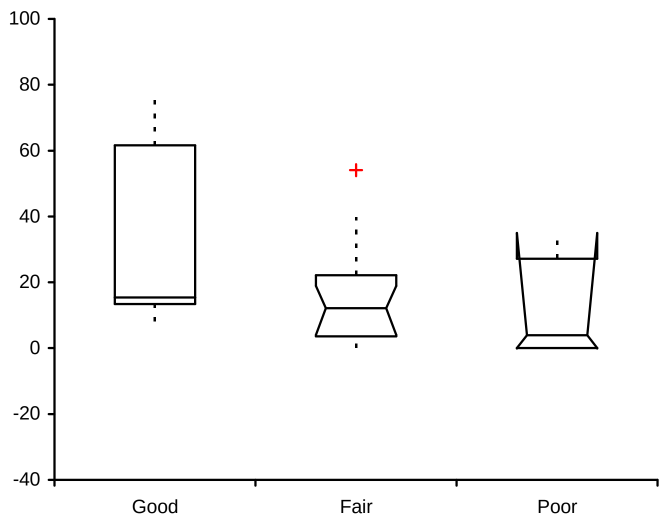
Performed by Neil Haugerud | **Date** 26 October 2004



PredTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	5.000	3.5590	1.7795	0.812 to 9.188	5.500	5.500	- to -
Fair	19	4.474	3.0978	0.7107	3.241 to 5.706	4.000	4.500	2.000 to 6.000
Poor	5	3.800	2.1679	0.9695	1.733 to 5.867	3.000	3.000	2.000 to 7.000

analysed with: Analyse-it + General 1.67

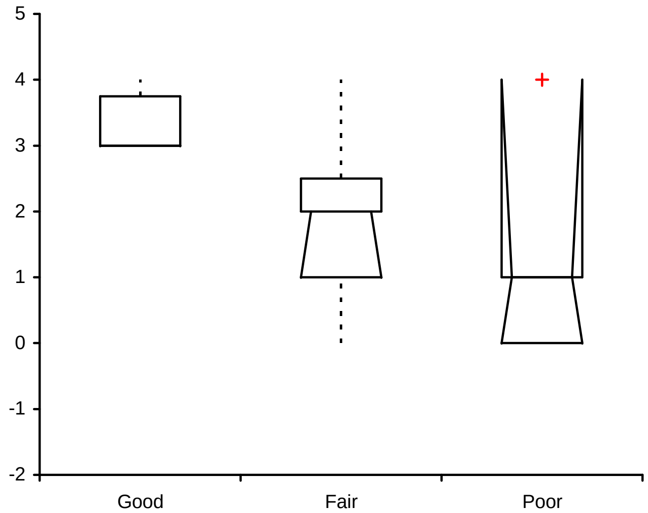
Test	**Comparative descriptives**
	Percent Scrapers by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



ScrapPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	29.007	32.1687	16.0844	-8.846 to 66.859	15.440	48.163	- to -
Fair	19	15.473	15.1219	3.4692	9.457 to 21.489	12.162	18.642	4.032 to 18.868
Poor	5	13.224	16.6131	7.4296	-2.615 to 29.063	3.960	27.160	0.000 to 35.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Scraper Taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



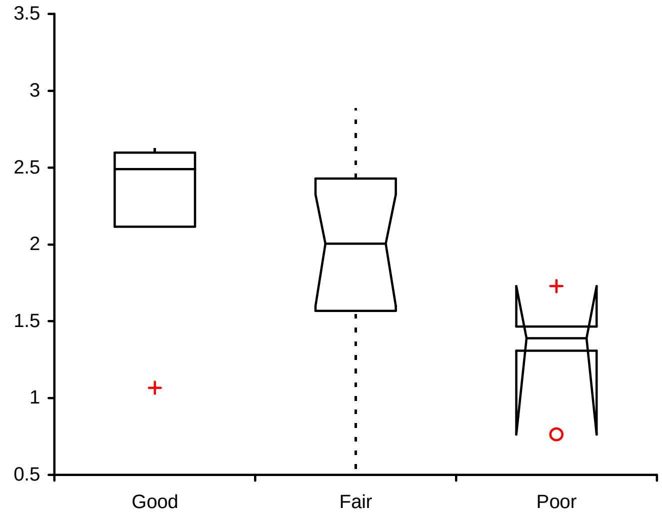
ScrapTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	3.250	0.5000	0.2500	2.662 to 3.838	3.000	0.750	- to -
Fair	19	2.000	1.2472	0.2861	1.504 to 2.496	2.000	1.500	1.000 to 2.000
Poor	5	1.200	1.6432	0.7348	-0.367 to 2.767	1.000	1.000	0.000 to 4.000

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Shannon-Weiner Diversity Index by HDI rating

Performed by | Neil Haugerud | **Date** | 26 October 2004



Shan_e by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	2.168	0.7367	0.3683	1.301 to 3.035	2.490	0.482	- to -
Fair	19	1.875	0.6999	0.1606	1.596 to 2.153	2.004	0.862	1.599 to 2.325
Poor	5	1.331	0.3543	0.1584	0.993 to 1.669	1.390	0.158	0.764 to 1.729

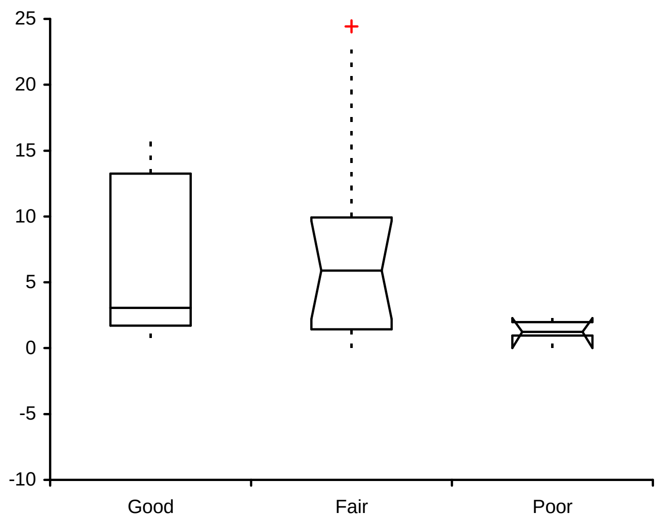
analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Percent Shredders by HDI rating

Performed by | Neil Haugerud

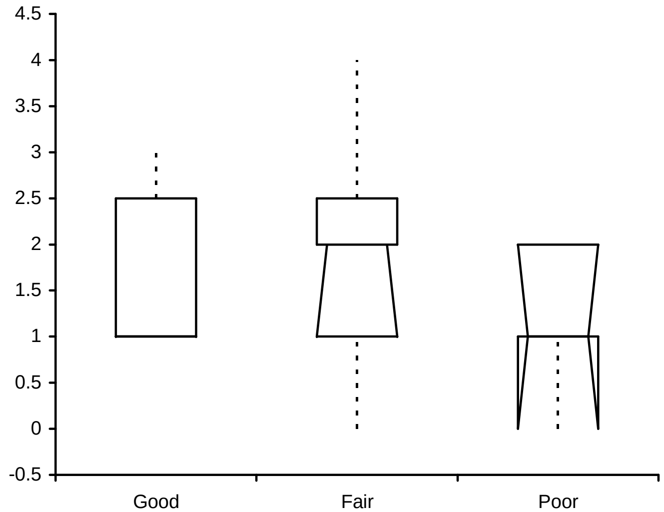
Date | 26 October 2004



ShredPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	5.804	7.1431	3.5716	-2.601 to 14.209	3.048	11.537	- to -
Fair	19	7.873	8.1735	1.8751	4.622 to 11.125	5.882	8.510	2.222 to 9.677
Poor	5	1.292	0.8960	0.4007	0.437 to 2.146	1.235	1.009	0.000 to 2.273

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Shredder Taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004

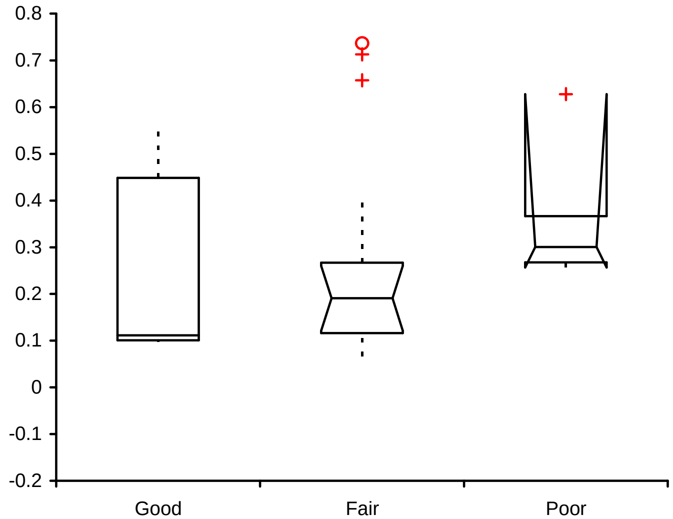


ShredTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	1.500	1.0000	0.5000	0.323 to 2.677	1.000	1.500	- to -
Fair	19	1.789	1.1343	0.2602	1.338 to 2.241	2.000	1.500	1.000 to 2.000
Poor	5	1.200	0.8367	0.3742	0.402 to 1.998	1.000	1.000	0.000 to 2.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Shannon Index by HDI rating
Performed by	Neil Haugerud

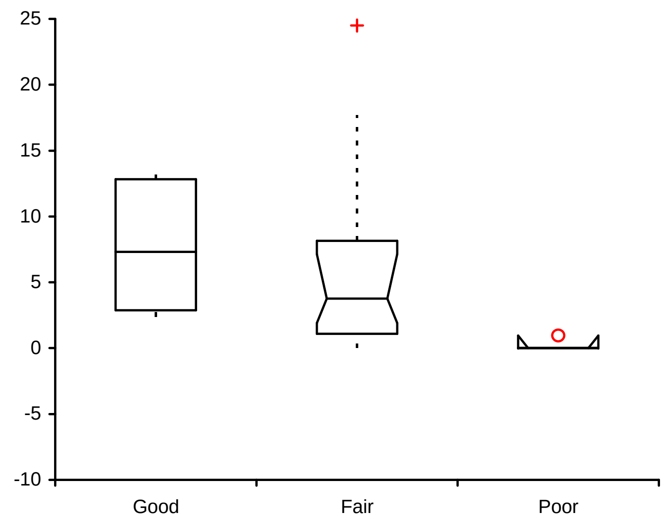
Date 26 October 2004



D by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	0.219	0.2258	0.1129	-0.046 to 0.485	0.111	0.347	- to -
Fair	19	0.262	0.2131	0.0489	0.178 to 0.347	0.191	0.151	0.121 to 0.260
Poor	5	0.364	0.1535	0.0687	0.217 to 0.510	0.300	0.099	0.256 to 0.627

analysed with: Analyse-it + General 1.67

Test	Comparative descriptives		
	Percent Sprawlers by HDI rating		
Performed by	Neil Haugerud	Date	26 October 2004



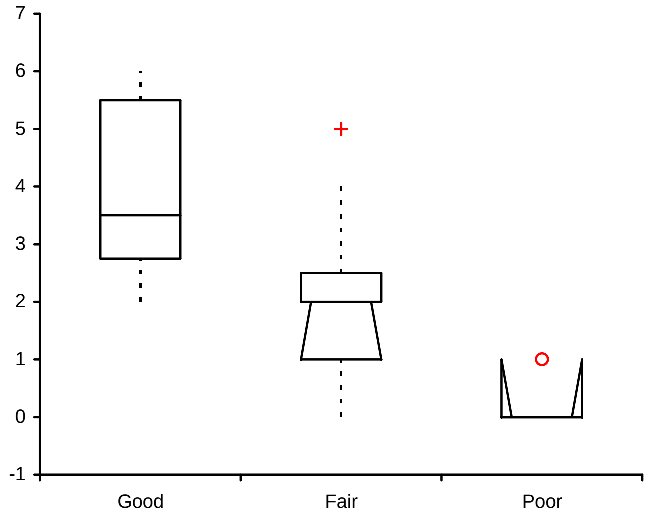
SprwlPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	7.565	5.6488	2.8244	0.918 to 14.212	7.307	9.956	- to -
Fair	19	5.679	6.5418	1.5008	3.076 to 8.281	3.774	7.066	1.905 to 7.143
Poor	5	0.194	0.4342	0.1942	-0.220 to 0.608	0.000	0.000	0.000 to 0.971

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Sprawler Taxa by HDI rating

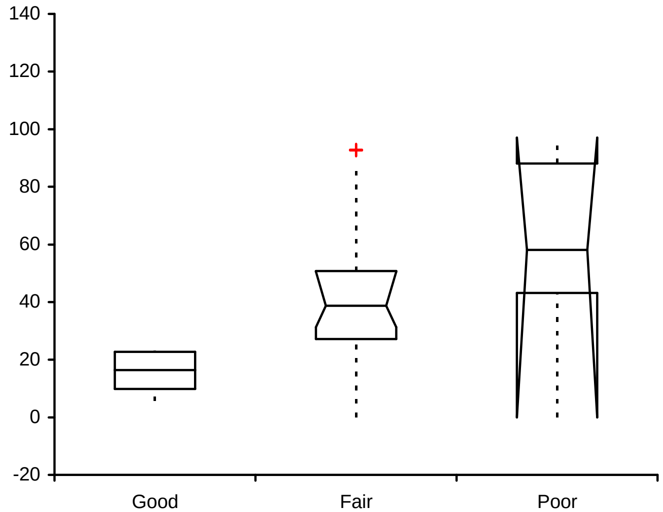
Performed by Neil Haugerud — **Date** 26 October 2004



SprwlTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	3.750	1.7078	0.8539	1.740 to 5.760	3.500	2.750	- to -
Fair	19	1.895	1.6294	0.3738	1.247 to 2.543	2.000	1.500	1.000 to 2.000
Poor	5	0.200	0.4472	0.2000	-0.226 to 0.626	0.000	0.000	0.000 to 1.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Swimmers by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



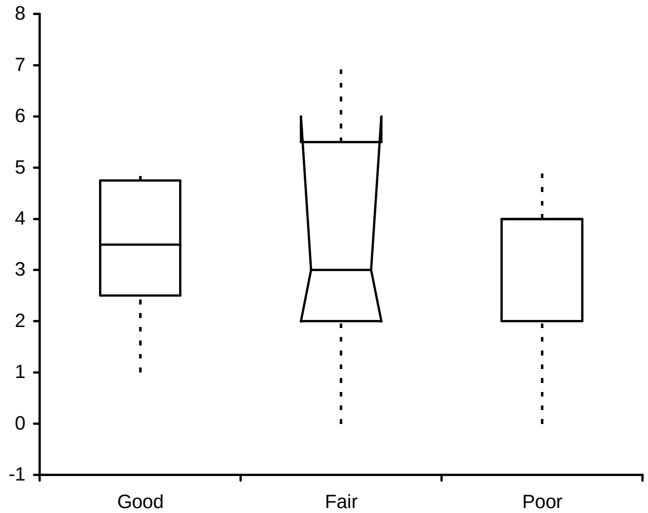
SwmmrPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	15.321	8.3465	4.1732	5.500 to 25.142	16.339	12.819	- to -
Fair	19	43.685	27.5566	6.3219	32.723 to 54.648	38.710	23.673	31.250 to 50.549
Poor	5	57.283	38.7813	17.3435	20.309 to 94.256	58.025	44.937	0.000 to 97.087

analysed with: Analyse-it + General 1.62

Test | **Comparative descriptives**

Swimmer Taxa by HDI rating

Performed by Neil Haugerud **Date** 26 October 2004



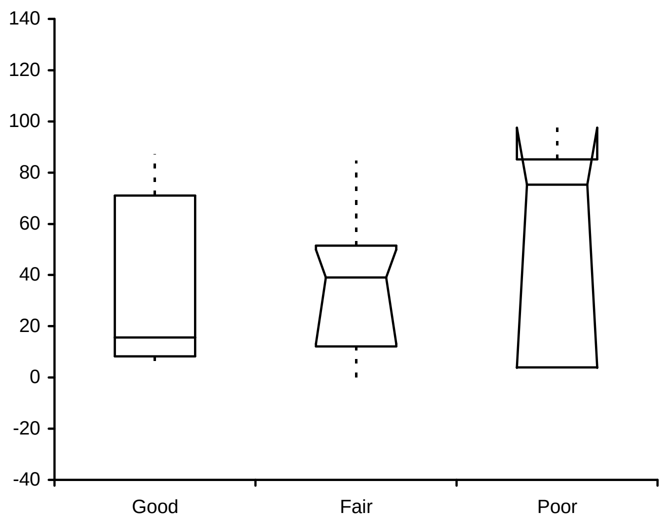
SwmmrTax by Index rating	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Good	4	3.250	1.7078	0.8539	0.532 to 5.968	3.500	2.250	- to -
Fair	19	3.684	2.2865	0.5246	2.582 to 4.786	3.000	3.500	2.000 to 6.000
Poor	5	3.000	2.0000	0.8944	0.517 to 5.483	4.000	2.000	- to -

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Percent Tolerant Taxa by HDI rating

Performed by | **Date** 26 October 2004



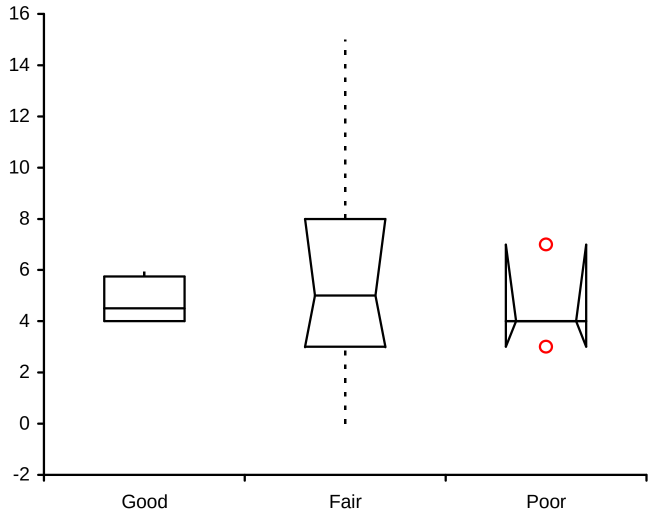
TolerPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	31.282	38.0004	19.0002	-13.433 to 75.996	15.631	62.838	- to -
Fair	19	34.574	24.7468	5.6773	24.729 to 44.418	39.048	39.322	13.187 to 50.000
Poor	5	53.176	45.6445	20.4128	9.659 to 96.693	75.309	81.267	3.883 to 97.500

analysed with: Analyse-it + General 1.67

Test | **Comparative descriptives**

Tolerant taxa by HDI rating

Performed by | Neil Haugerud — **Date** | 26 October 2004

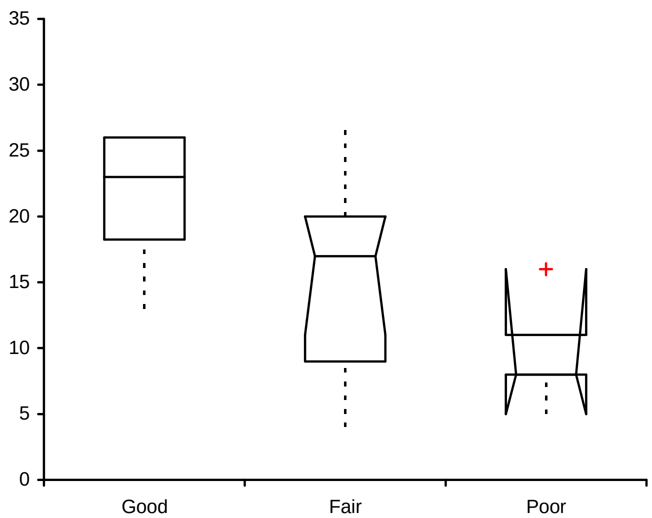


TolerTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	4.750	0.9574	0.4787	3.623 to 5.877	4.500	1.750	- to -
Fair	19	5.789	4.0080	0.9195	4.195 to 7.384	5.000	5.000	3.000 to 8.000
Poor	5	4.400	1.5166	0.6782	2.954 to 5.846	4.000	0.000	3.000 to 7.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Total Taxa by HDI rating
Performed by	Neil Haugerud

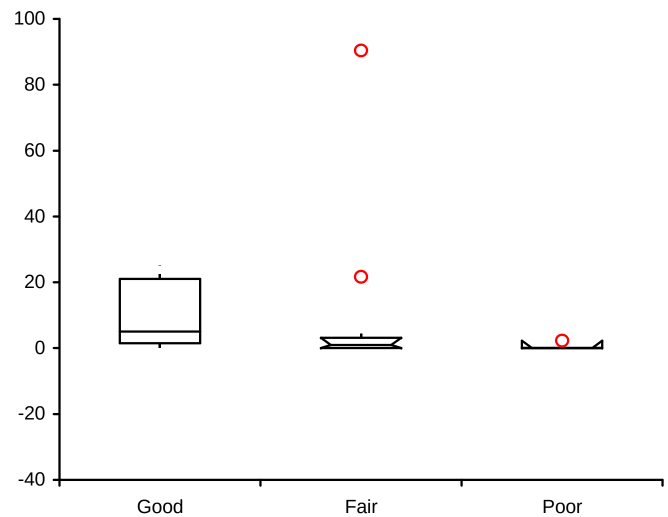
Date 26 October 2004



TotalTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	21.250	6.1847	3.0923	13.973 to 28.527	23.000	7.750	- to -
Fair	19	15.263	7.0304	1.6129	12.466 to 18.060	17.000	11.000	11.000 to 20.000
Poor	5	9.600	4.1593	1.8601	5.635 to 13.565	8.000	3.000	5.000 to 16.000

analysed with: Analyse-it + General 1.67

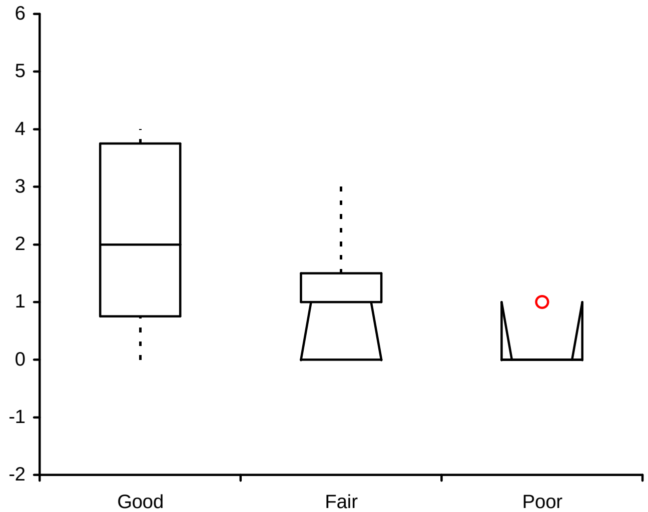
Test	**Comparative descriptives**
	Percent Trichoptera by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



TrichPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	8.872	11.4922	5.7461	-4.650 to 22.395	5.088	19.488	- to -
Fair	19	7.130	20.7832	4.7680	-1.138 to 15.398	0.952	3.175	0.000 to 3.125
Poor	5	0.455	1.0164	0.4545	-0.514 to 1.424	0.000	0.000	0.000 to 2.273

analysed with: Analyse-it + General 1.67

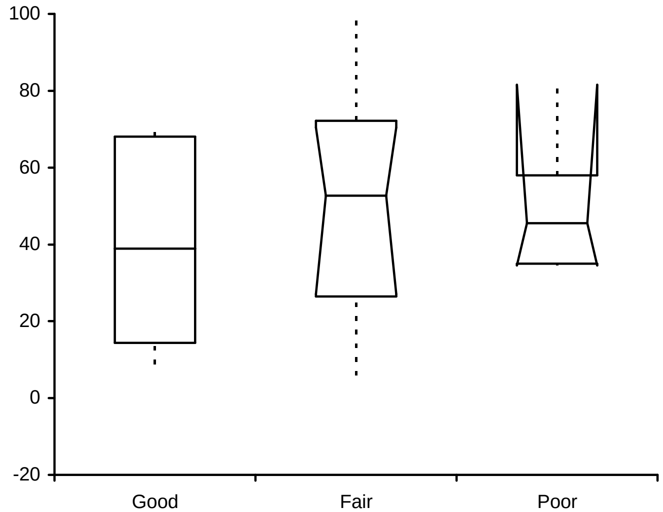
Test	**Comparative descriptives**
	Trichoptera taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



TrichTax by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	2.000	1.8257	0.9129	-0.148 to 4.148	2.000	3.000	- to -
Fair	19	0.947	1.0260	0.2354	0.539 to 1.356	1.000	1.500	0.000 to 1.000
Poor	5	0.200	0.4472	0.2000	-0.226 to 0.626	0.000	0.000	0.000 to 1.000

analysed with: Analyse-it + General 1.67

Test	**Comparative descriptives**
	Percent Univoltine taxa by HDI rating
Performed by	Neil Haugerud
Date	26 October 2004



UniVolPct by Index rating	n	Mean	SD	SE	90% CI of Mean	Median	IQR	90% CI of Median
Good	4	39.197	31.1491	15.5745	2.545 to 75.850	38.945	53.590	- to -
Fair	19	52.458	28.4645	6.5302	41.134 to 63.782	52.688	45.732	27.059 to 70.408
Poor	5	50.924	19.6063	8.7682	32.232 to 69.617	45.545	22.955	34.568 to 81.553

Appendix E

Landscape Index Scores, Habitat Rankings, Habitat Scores and Raw Metric Scores

Table E-1. Landscape Index Scores Calculated Using the Analytical Tools Interface for Landscape Assessments (ATtILA, Version 3.0) for Glide/Pool Stream Reaches of the Lake Agassiz Plain Ecoregion (48) Within North Dakota for the Sites Used in the Metric Development. (Abbreviations defined below Table E-2.)

Storet Number	Stream name	HDI Rank	AGPSL3	AGCSL3	RAGC30	RNG30	RDDENS	P_LOAD	Landscape Index Score	HDI Score
551226	Turtle River	Good	5	18	19	4	9	17	72	112.50
551248	Sheyenne River	Good	16	9	17	10	5	15	72	119.50
551246	Sheyenne River	Good	9	12	17	7	6	12	63	120.00
551106	Tongue River	Good	2	7	16	2	13	1	41	126.83
551162	Bois de Sioux River	Poor	1	1	20	20	17	20	79	71.17
551154	Goose River North Branch	Poor	5	12	19	13	17	17	83	77.33
551161	Antelope Creek	Poor	2	10	20	11	12	19	74	78.83
551227	Forest River	Poor	2	2	17	3	17	18	59	81.33
551147	Rush River	Poor	1	1	19	11	17	16	65	83.33
551155	Goose River	Fair	18	4	17	20	15	13	87	86.00
551158	Wild Rice River	Fair	2	2	19	10	19	17	69	87.00
551221	Sheyenne River	Fair	12	11	16	9	7	18	73	93.67
551153	Goose River	Fair	2	11	20	12	15	19	79	94.17
551229	Park River	Fair	1	5	18	1	9	15	49	95.17
551159	Wild Rice River	Fair	2	9	20	12	10	18	71	95.33
551156	Goose River Middle Branch	Fair	4	17	20	14	12	17	84	96.00
551151	Elm River	Fair	2	2	17	8	17	17	63	99.00
551164	Swan Creek	Fair	2	2	20	11	15	16	66	99.00
551107	Tongue River	Fair	1	1	20	9	16	18	65	99.33
551152	Elm River North Branch	Fair	1	1	15	7	16	17	57	100.00
551222	Sheyenne River	Fair	9	9	18	10	11	16	73	100.67
551160	Wild Rice River	Fair	3	6	19	8	12	19	67	101.17
551220	Dead Colt Creek	Fair	8	14	18	3	7	16	66	103.50
551232	Park River Middle Branch	Fair	1	3	20	5	10	18	57	104.50
551146	Turtle River	Fair	3	4	17	8	15	2	49	105.17
551228	Forest River	Fair	1	1	20	13	18	20	73	107.17
551108	Pembina River	Fair	1	5	19	1	12	15	53	107.33
551225	Kellys Slough	Fair	3	5	17	7	16	4	52	107.67

Table E-2. Landscape Index Scores Calculated Using the Analytical Tools Interface for Landscape Assessments (ATtILA, Version 3.0) for Glide/Pool Stream Reaches of the Lake Agassiz Plain Ecoregion (48) Within North Dakota for the Validation and Between-Year Revisit Sites.

Storet Number	Stream name	Site Type	HDI Rank	AGPSL3	AGCSL3	RAGC30	RNG30	RDDENS	P_LOAD	Landscape Index Score	HDI Score
551165	Maple River	Validation	Poor	4	3	16	8	18	19	68	82.83
551231	Pembina River	Validation	Good	1	4	19	2	12	12	50	117.33
551247	Sheyenne River	Validation	Fair	8	19	16	10	11	19	83	107.33
551163	Red River	Validation	Fair	1	1	20	19	14	20	75	107.50
551150	Elm River	Validation	Fair	2	2	17	5	15	19	60	99.00
551163	Red River	Revisit	Fair	1	1	20	19	14	20	75	107.50
551220	Dead Colt Creek	Revisit	Fair	8	14	18	3	7	16	66	103.50
551221	Sheyenne River	Revisit	Fair	12	11	16	9	7	18	73	95.17
551222	Sheyenne River	Revisit	Fair	9	9	18	10	11	16	73	94.67

Table E-3. Habitat Rankings, Habitat Scores and Raw Metric Scores Used to Calculate the Macroinvertebrate IBI for Glide/Pool Stream Reaches of the Lake Agassiz Plain Ecoregion (48) Within North Dakota for the Sites Used in the Metric Development.

Storet Number	Date Collected	HDI Rank	HDI Score	DipPct	SwmmrPct	Dom01Pct	CllctTax	BrrwrTax	ClngrTax	TotalTax
551226	08/20/1996	Good	112.50	4.76	5.56	73.81	6.00	2.00	6.00	13.00
551248	09/20/2002	Good	119.50	42.19	11.25	15.63	8.00	8.00	8.00	26.00
551246	09/20/2002	Good	120.00	26.44	23.05	20.34	8.00	8.00	7.00	26.00
551106	08/28/1996	Good	126.83	59.18	21.43	21.43	7.00	3.00	6.00	20.00
551162	08/22/1995	Poor	71.17	39.77	43.18	39.77	1.00	2.00	1.00	8.00
551154	08/14/1996	Poor	77.33	2.97	88.12	48.51	5.00	3.00	2.00	11.00
551161	08/21/1995	Poor	78.83	0.00	0.00	35.00	0.00	0.00	1.00	5.00
551227	08/21/1996	Poor	81.33	1.94	97.09	77.67	0.00	1.00	0.00	8.00
551147	08/24/1995	Poor	83.33	0.62	58.02	45.06	2.00	1.00	6.00	16.00
551155	08/14/1996	Fair	86.00	8.60	38.71	38.71	5.00	2.00	5.00	19.00
551158	08/21/1995	Fair	87.00	0.00	86.29	80.65	0.00	1.00	1.00	7.00
551221	10/23/1995	Fair	93.67	1.92	92.65	84.03	0.00	2.00	1.00	11.00
551153	08/14/1996	Fair	94.17	1.35	22.97	20.27	5.00	2.00	8.00	21.00
551229	08/28/1996	Fair	95.17	14.29	80.00	29.52	4.00	4.00	4.00	19.00
551159	08/21/1995	Fair	95.33	0.00	0.00	85.22	0.00	0.00	3.00	5.00
551156	08/14/1996	Fair	96.00	28.09	19.10	19.10	7.00	5.00	5.00	20.00
551151	08/13/1996	Fair	99.00	0.00	35.56	24.44	2.00	2.00	4.00	13.00
551164	08/23/1995	Fair	99.00	0.00	41.51	41.51	0.00	0.00	2.00	6.00
551107	08/28/1996	Fair	99.33	20.88	50.55	48.35	4.00	2.00	5.00	17.00
551152	08/13/1996	Fair	100.00	19.39	51.02	27.55	7.00	5.00	3.00	23.00
551222	10/23/1995	Fair	100.67	2.86	45.40	37.46	2.00	2.00	3.00	20.00
551160	08/22/1995	Fair	101.17	0.00	35.29	35.29	1.00	2.00	2.00	6.00
551220	10/23/1995	Fair	103.50	0.00	92.86	46.43	1.00	0.00	2.00	4.00
551232	08/28/1996	Fair	104.50	13.27	50.00	29.59	4.00	2.00	4.00	20.00
551146	08/19/1996	Fair	105.17	30.59	2.35	48.24	6.00	1.00	8.00	16.00
551228	08/21/1996	Fair	107.17	53.92	21.57	15.69	17.00	6.00	4.00	27.00
551108	09/24/1996	Fair	107.33	19.79	31.25	19.79	6.00	3.00	6.00	23.00
551225	08/20/1996	Fair	107.67	60.00	32.94	20.00	6.00	5.00	1.00	13.00

Table E-4. Habitat Rankings, Habitat Scores and Raw Metric Scores Used to Calculate the Macroinvertebrate IBI for Glide/Pool Stream Reaches of the Lake Agassiz Plain Ecoregion (48) Within North Dakota for the Validation and Between-Year Revisit Sites.

Storet Number	Date Collected	Site Type	HDI Rank	HDI Score	DipPct	SwmmrPct	Dom01Pct	CllctTax	BrrwrTax	ClngrTax	TotalTax
551165	08/23/1995	Validation	Poor	82.83	0.00	29.17	29.17	0.00	1.00	0.00	5.00
551231	09/24/1996	Validation	Good	117.33	2.15	36.56	33.33	5.00	5.00	5.00	18.00
551247	09/20/2002	Validation	Fair	107.33	44.18	29.45	34.93	11.00	9.00	6.00	27.00
551163	08/22/1995	Validation	Fair	107.50	0.76	6.06	35.61	3.00	2.00	6.00	14.00
551150	08/13/1996	Validation	Fair	99.00	5.05	47.47	38.38	2.00	0.00	2.00	10.00
551163	09/10/1996	Revisit	Fair	107.50	6.29	41.32	29.94	9.00	3.00	14.00	41.00
551220	09/16/1996	Revisit	Fair	103.50	3.00	48.00	24.00	7.00	4.00	2.00	20.00
551221	09/16/1996	Revisit	Fair	95.17	4.49	58.43	58.43	3.00	1.00	7.00	14.00
551222	09/16/1996	Revisit	Fair	94.67	1.00	72.91	47.16	8.00	3.00	9.00	26.00

Table E-5. Individual Metric Scores and IBI Score for the Macroinvertebrate IBI Developed for Glide/Pool Stream Reaches of the Lake Agassiz Plain Ecoregion (48) Within North Dakota for the Sites Used in the Metric Development.

Storet Number	HDI Rank	DipPct	SwmmrPct	Dom01Pct	CllctTax	BrrwrTax	ClngrTax	TotalTax	IBI Score
551226	Good	8	94	16	46	25	75	48	45
551248	Good	71	88	100	62	100	100	96	88
551246	Good	44	76	93	62	100	88	96	80
551106	Good	99	77	92	54	38	75	74	73
551162	Poor	67	55	65	8	25	13	30	37
551154	Poor	5	7	52	38	38	25	41	29
551161	Poor	0	100	72	0	0	13	19	29
551227	Poor	3	0	10	0	13	0	30	8
551147	Poor	1	39	57	15	13	75	59	37
551155	Fair	14	59	67	38	25	63	70	48
551158	Fair	0	9	6	0	13	13	26	9
551221	Fair	3	3	1	0	25	13	41	12
551153	Fair	2	76	93	38	25	100	78	59
551229	Fair	24	16	80	31	50	50	70	46
551159	Fair	0	100	0	0	0	38	19	22
551156	Fair	47	80	95	54	63	63	74	68
551151	Fair	0	63	87	15	25	50	48	41
551164	Fair	0	56	63	0	0	25	22	24
551107	Fair	35	47	53	31	25	63	63	45
551152	Fair	33	46	83	54	63	38	85	57
551222	Fair	5	52	68	15	25	38	74	40
551160	Fair	0	63	72	8	25	25	22	31
551220	Fair	0	2	55	8	0	25	15	15
551232	Fair	22	47	80	31	25	50	74	47
551146	Fair	51	98	53	46	13	100	59	60
551228	Fair	90	77	100	100	75	50	100	85
551108	Fair	33	67	94	46	38	75	85	63
551225	Fair	100	65	94	46	63	13	48	61

Table E-6. Individual Metric Scores for the Macroinvertebrate IBI Developed for Glide/Pool Stream Reaches of the Lake Agassiz Plain Ecoregion (48) Within North Dakota for the Validation and Between-Year Revisit Sites.

Storet Number	Site Type	HDI Rank	DipPct	SwmmrPct	Dom01Pct	CllctTax	BrrwrTax	ClngrTax	TotalTax	IBI Score
551165	Validation	Poor	0	69	80	0	13	0	19	26
551231	Validation	Good	4	62	74	38	63	63	67	53
551247	Validation	Fair	74	69	72	85	100	75	100	82
551163	Validation	Fair	1	94	71	23	25	75	52	49
551150	Validation	Fair	8	50	67	15	0	25	37	29
551163	Revisit	Fair	11	57	79	69	38	100	100	65
551220	Revisit	Fair	5	50	88	54	50	25	74	49
551221	Revisit	Fair	8	39	38	23	13	88	52	37
551222	Revisit	Fair	2	23	54	62	38	100	96	54